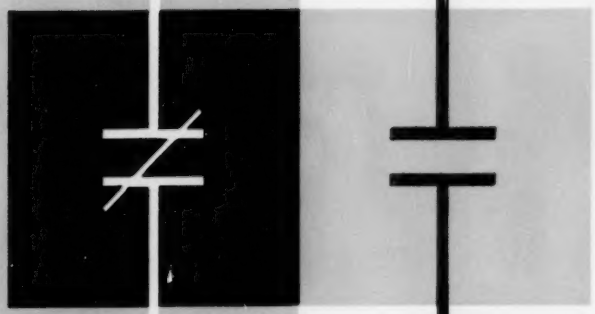
MARCH 30, 1961

# MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



## Precision Snap-Action Switches

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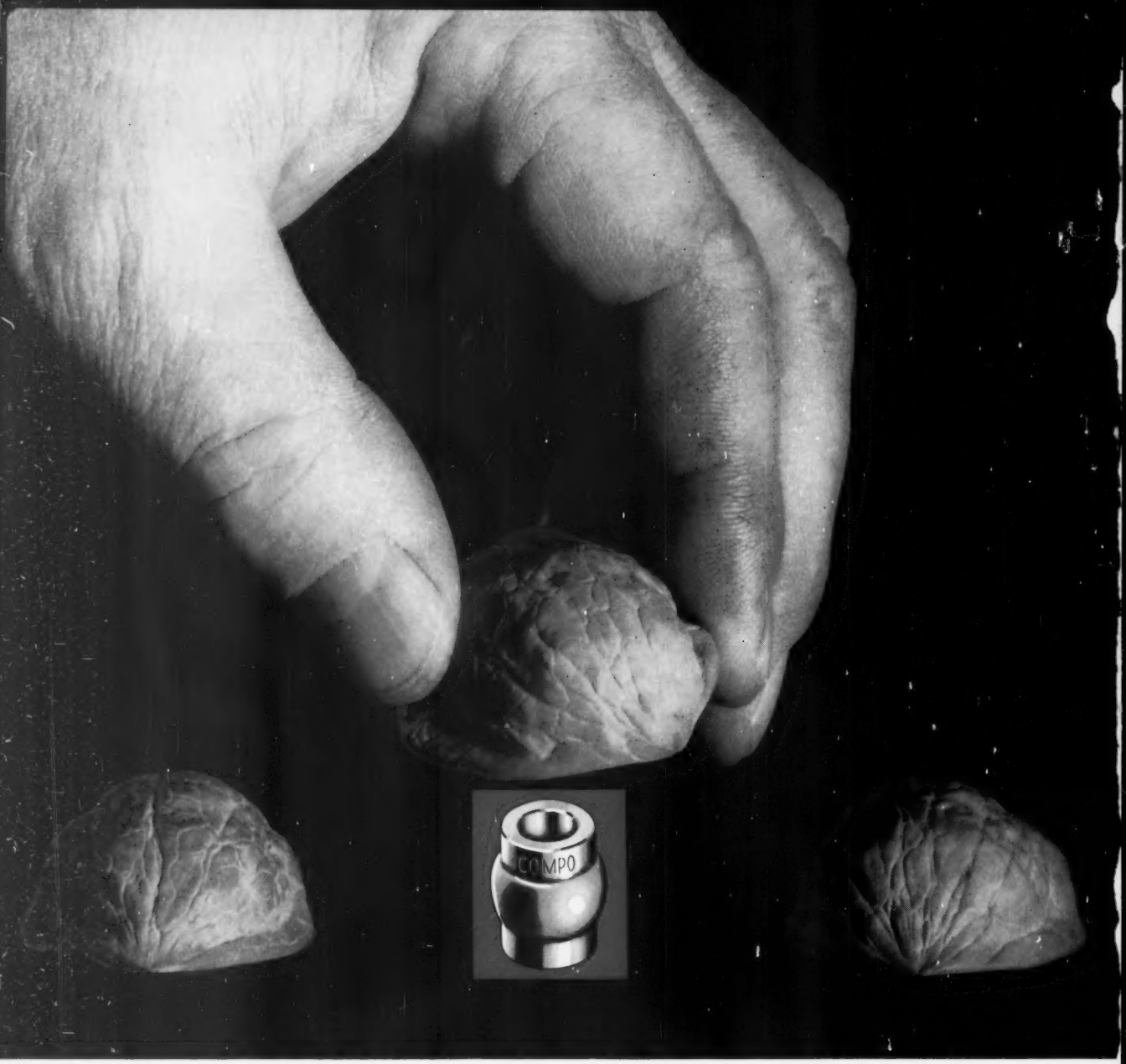
FARNSWORTH




# No place for guessing games!

The right choice of materials is certain when you bring your bearing problems to Bound Brook. Choosing from over 25 grades of sintered iron and bronze, our powder metallurgy engineers select the material with exactly the right properties for *your* application . . . the right balance of hardness, strength, ductility, density and thermal conductivity to fit your needs. They can create many special properties for you, too, by varying the composition of the metal powders. Your choice is always right when you choose Bound Brook for your bearings.

**BOUND BROOK BEARING**
**CORPORATION OF AMERICA**
A BIRFIELD COMPANY

*Pioneer in Powder Metallurgy Bearings and Parts • Plants at Bound Brook, N.J. and Sturgis, Mich*

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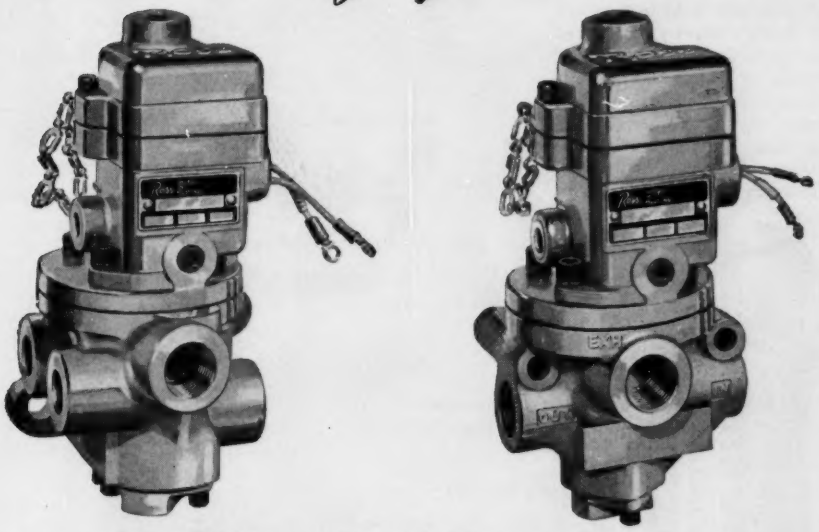
**THANK YOU . . .**

for your enthusiastic response to this announcement. Because it has been viewed as an important advance in valve development, we reprint this news for those who missed its first appearance.

# Ross

## *Proudly presents*



THE NEW "HEADLINE" SERIES

*A complete new series of inline valves, sizes one-quarter inch through one and one-half inch, straightway, 3-way and 4-way. These valves, size for size, will operate faster, longer, and provide greater capacity than any other valves we have been able to find.*

*When the price, quality and performance and Ross reputation are taken together in evaluating this series, it represents probably the best valve value available today. Before you specify any valve after today, you owe it to yourself to look into the "Headline" series. Write for full information.*

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**Ross** OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICHIGAN



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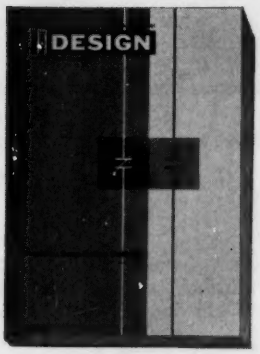


**Front Cover:** The open and shut case for switches is presented by George Farnsworth on this issue's cover. For precision switches, authors R. C. Froehlich and E. E. Leird begin a two-part presentation on Page 116 to help in making design decisions.

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CONTINUED NEXT PAGE

**IN THE NEXT ISSUE:** Phases of managerial planning . . . principles of pressure regulators . . . elastic-body mechanics . . . precision snap-action switches . . . positioning gear shafts . . . fatigue in welded metal joints . . . designing cam profiles.

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

**March 30, 1961**
**Volume 33 — No. 7**





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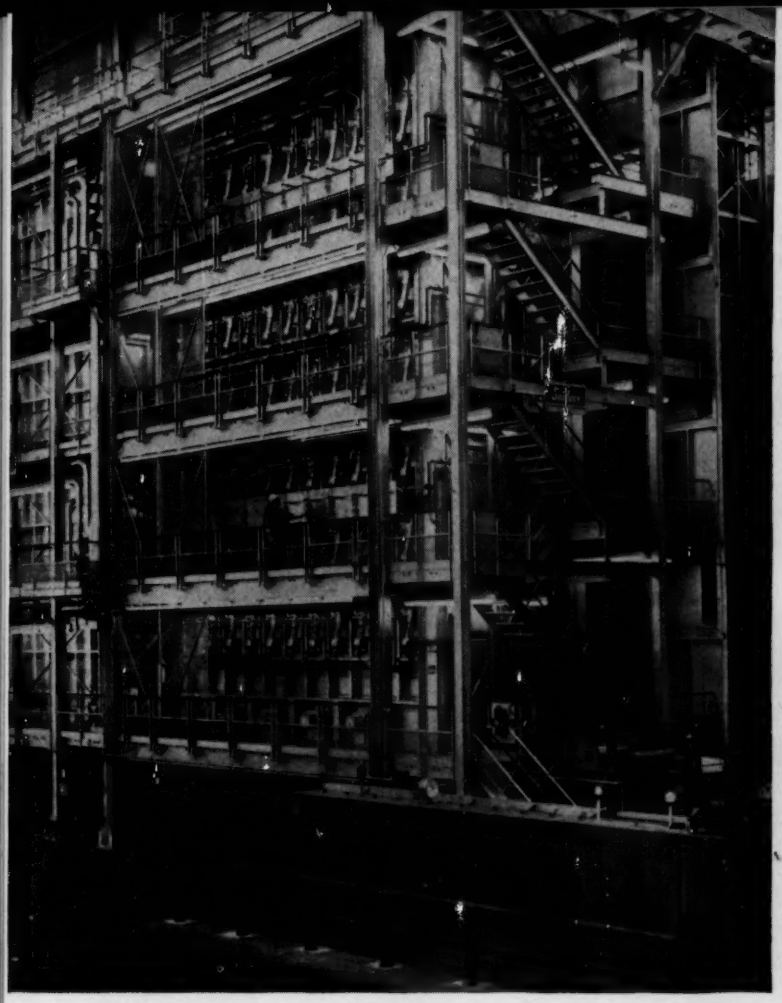
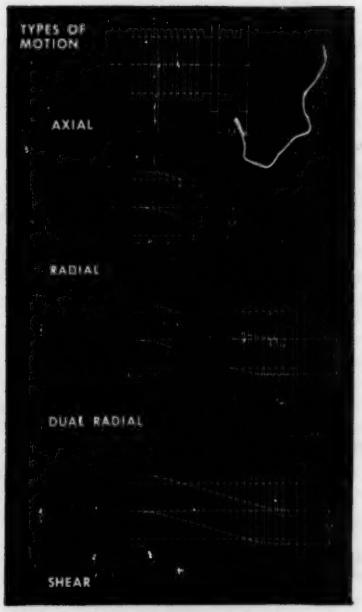


A view of the U.S. Steel's giant annealing furnace in Pittsburg, Calif. Coils are welded together so that a mile-long strip is constantly moving through the series of heating, soaking and cooling zones in roller-coaster fashion at speeds up to 1500 feet per minute.

Anaconda A-X flexible connectors installed at roll-shafts absorb thermal expansion and contraction and seal in inert gas furnace atmosphere.

Anaconda A-X stainless steel flexible connectors on flue-gas lines compensate for thermal expansion and contraction.

# ANACONDA A-X FLEXIBLE CONNECTORS PROTECT PIPING, SEAL ROLL-SHAFTS IN LARGE ANNEALING FURNACE




Continuous strip annealing furnace temperatures cause a variety of movements due to thermal expansion and contraction. To absorb this movement in flue-gas lines and to provide shaft seals on rolls, Surface Combustion Division of Midland-Ross Corp., designers and builders of U.S. Steel's giant furnace, installed hundreds of Anaconda A-X stainless steel flexible connectors.

Anaconda A-X Tubing is a flexible metal connector designed to handle the types of movement shown at left while conveying liquid and gas over a wide range of temperatures. It is available in stainless steel and other alloys and is generally sold complete with fittings. Nominal tubing I.D.'s: 5″, 6″, 8″, 10″, 14″. For complete details, write for Bulletin A-X 97 or call your Anaconda Metal Hose representative. Anaconda Metal Hose, Box 791, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6129

## ANACONDA® METAL HOSE

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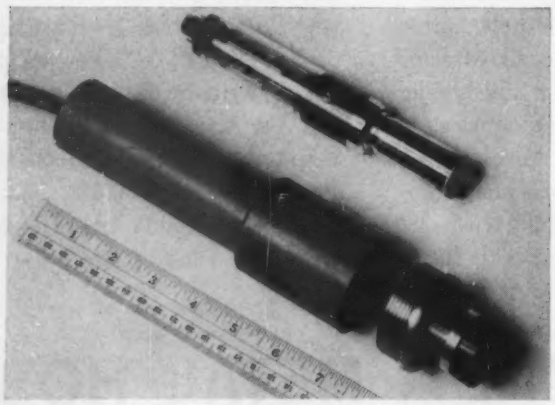
# 'Telescope' Houses Radar Screen

PITTSBURGH—Radar becomes a practical accessory for private planes and boats with the introduction of a miniature "private-eye" display device. It will cost about $150 when in quantity production. Described by Westinghouse Electric Corp. as having the shape, size, weight, and convenience of a telescope, the hand-held unit can be viewed by only one person at a time.

Essential element of the "eye" is a high-resolution cathode-ray tube 7 in. long. The tube's 0.60-in. diam screen is observed through a magnifying eye piece which, by enlarging ten times, shows the equivalent of a 6-in. screen observed from a distance of 10 in. The screen is aluminized and cathephoretically deposited to insure high resolution—900 lines per diameter is realized.

On a small plane, the pilot would keep the "telescope" part of the equipment handy for checking the weather he is flying into, and the transceiver would probably be located elsewhere, for best weight distribution.

Because it operates effectively under ambient lighting bright enough to wash out displays on large open screens, the new radar-TV display may also be used for outdoor applications requiring a portable monitor not affected by daylight, closed-circuit systems for automobile traffic control, large construction projects, tactical military operations, and three-dimensional display systems for medical and biological microscopy.



**Contained in an 8½-in. long, 20-oz assembly,** components of the radar-television display device developed at Westinghouse's electronic tube division include a screen and a WX 4527 tube. The tube is electrostatically focused and magnetically deflected with an angle of about 34 deg. All voltages, including deflection-yoke voltage, are introduced through flying leads.

# . . . Fluid Power news

OILGEAR 40 Years of Fluid Power

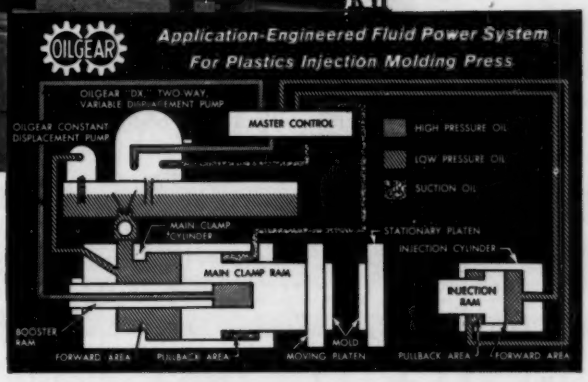
Report No. 11,602 From Oilgear *Application-Engineering* Files

## HOW OILGEAR ENGINEERING TEAMWORK AIDED DESIGN OF NEW INJECTION MOLDING MACHINES

**CUSTOMER:** *National Automatic Tool Co., Inc. (NATCO), Richmond, Indiana*

**DATA:** As a preliminary guide to design and production of a new line of injection molding machines, "NATCO" engineers used a 31-question survey of molders operating eight or more machines. This survey confirmed "NATCO" engineers' experienced opinion that: 1. Most unplanned downtime on injection molding machines was due primarily to hydraulic system problems . . . shocks caused by sudden shifts in pressure or direction of flow through valves "under pressure," causing pipe and welded joint fatigue, bent valve stems, cracked or over-stressed tie-rods and cylinders. 2 Molders' demands for higher speeds and pressures further amplify these problems. *Basic "NATCO" Requirements:* 1. A hydraulic system to eliminate shock, hammering, and the resulting costly downtime . . . must provide continuous, dependable, high-speed operation. 2. Both slow and high-speed closing, as well as two-speed injection control for faster molding cycles. 3. High-speed clamp action. 4. Precision control of speeds and pressures to insure high molding quality. 5. Must be a "clean" package . . . compact, leak-free, simple to install, fast and easy to maintain, quiet, conserve electrical power.


New "NATCO 400" Plastics Injection Molding Machine — one of four standard sizes. Note overhead position of the Oilgear pump and reservoir . . . away from dirt and molding-room traffic. This position permits fast gravity flow of oil from the reservoir through a prefill valve into the large clamp cylinder to speed operation. During the past year . . . a period of unusually low capital investment purchases . . . over 150 Oilgear Pumps have been put into operation on this new "NATCO" line.




Simplified schematic illustrates one phase of system operation — high-speed closing of clamp ram. Large clamp cylinder is being gravity-filled through prefill valve, while mold clamp is being advanced by small booster cylinder powered by Oilgear "DX" pump. Closing speed — 700 in./min. This circuit design provides clamp pressure build-up in a fraction of a second . . . one of the reasons for the fast cycles on the "NATCO 400."

**SOLUTION:** Cooperation and teamwork between "NATCO" and Oilgear engineers resulted in a new, shockless, *Fluid Power* System . . . basis of a revolutionary new line of high-speed, high-capacity, plastics injection molding machines. This system incorporates two Oilgear Pumps . . . one, a large capacity, radial piston, two-way, variable displacement type "DX" pump with remote electric control which alternately serves the mold clamp and injection rams; and a small capacity, constant displacement type "HG" pump which maintains a high, positive clamping force during injection cycle. Instead of using conventional valves "under pressure" to reverse clamp and injection rams, these functions are accomplished by reversing fluid flow in the Oilgear type "DX" pump. With this system, flow and pressure decelerates to zero *before* flow direction is changed . . . flow then accelerates to a preselected volume in the new direction — completely eliminating reversal shocks. No chokes or other controls on the master valve are necessary, as diverting of flow from clamp to injection rams is also made under ideal "no-flow" conditions, with absolutely no shock. Infinitely variable machine speeds are obtained by varying pump stroke, resulting in a minimum of heating and horsepower dissipation.

*For similar practical solutions to YOUR linear or rotary Controlled-Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .*

"NATCO," famous in machine tool and plastic molding machine fields, states — "*Although lower priced pumps could be secured, they basically did not offer the control features found in the Oilgear units. This is especially true of the larger capacity pump, which in addition to its variable and reversible features incorporates many auxiliary controls. It's more than just a pump . . . it contains auxiliary systems for pilot, supercharge, cooling, safety, and filtering. These pumps are quiet. They have an excellent injection molding machine service record . . .*"

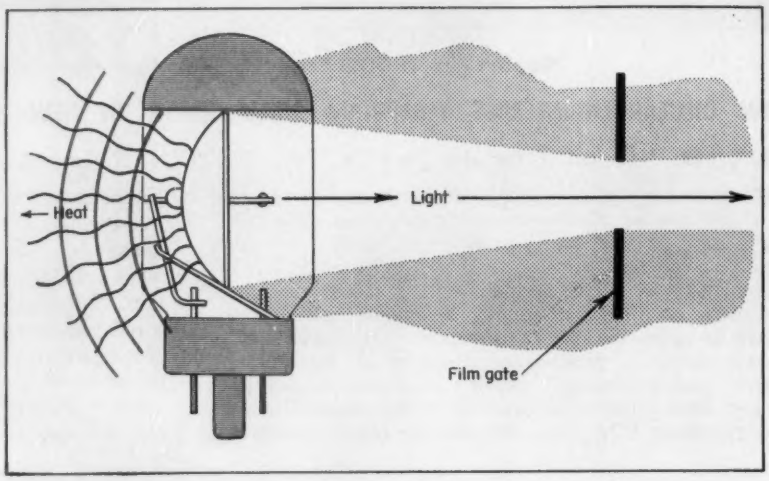
**THE OILGEAR COMPANY**

*Application-Engineered Controlled Motion Systems*

1568 WEST PIERCE STREET MILWAUKEE 4, WISCONSIN

## 'Split-Personality' Lamp Separates Heat from the Light

**DEF,** a new 150-w lamp for 8-mm home-movie projectors, cuts in half the heat reaching the film. Developed by General Electric Co., Cleveland, the lamp uses a heat-transmitting reflector to direct light rays to the film and heat rays out the back. The reflector is coated with dichroic filters that are actually multiple coatings of a metallic substance with the unique ability to reflect visible light and transmit the infrared. The cool beam prolongs film life and reduces fading and charring. Even single frames of color film can now be safely viewed. And according to GE, the new lamp will permit design of projectors to show brighter stills. The lamp was shown at the recent photo dealers' trade exhibit.



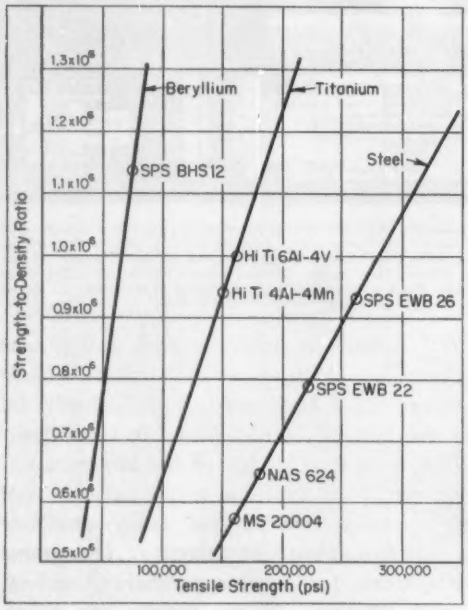

## New Process Strengthens Beryllium Bolts

JENKINTOWN, PA.—High strength-to-weight ratio of a new line of beryllium bolts, introduced by Standard Pressed Steel Co., reduces fastener weight in an assembly to almost half what it would be if steel bolts were used. The company points out that this factor is especially significant in space craft, where every pound designed out of a satellite means $1 million saved on the cost of putting it into orbit.

In developing the bolt, SPS disproved the theory that beryllium is inherently brittle and showed, instead, that the metal is sensitive to notches or surface discontinuities. Notch sensitivity was overcome by smoothing out microscopic scratches (made during fabrication) with a chemical surface finish and by specifying a rounded "corner" between head and shank. Thread-root radius is also large—1.5 to 2.5 times that of conventional rounded roots.

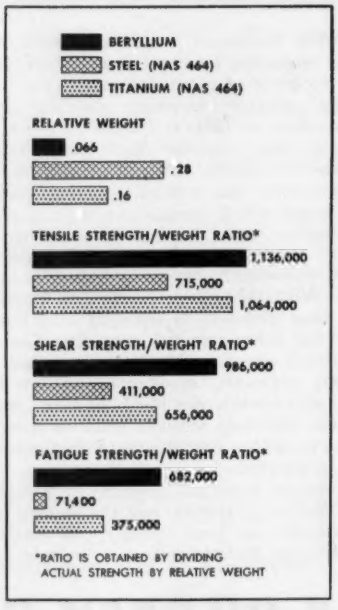
Beryllium parts had been considered incapable of good structural performance because they shattered under dynamic loading. However, fatigue strength has proved to be one of the most important features of the new fasteners.

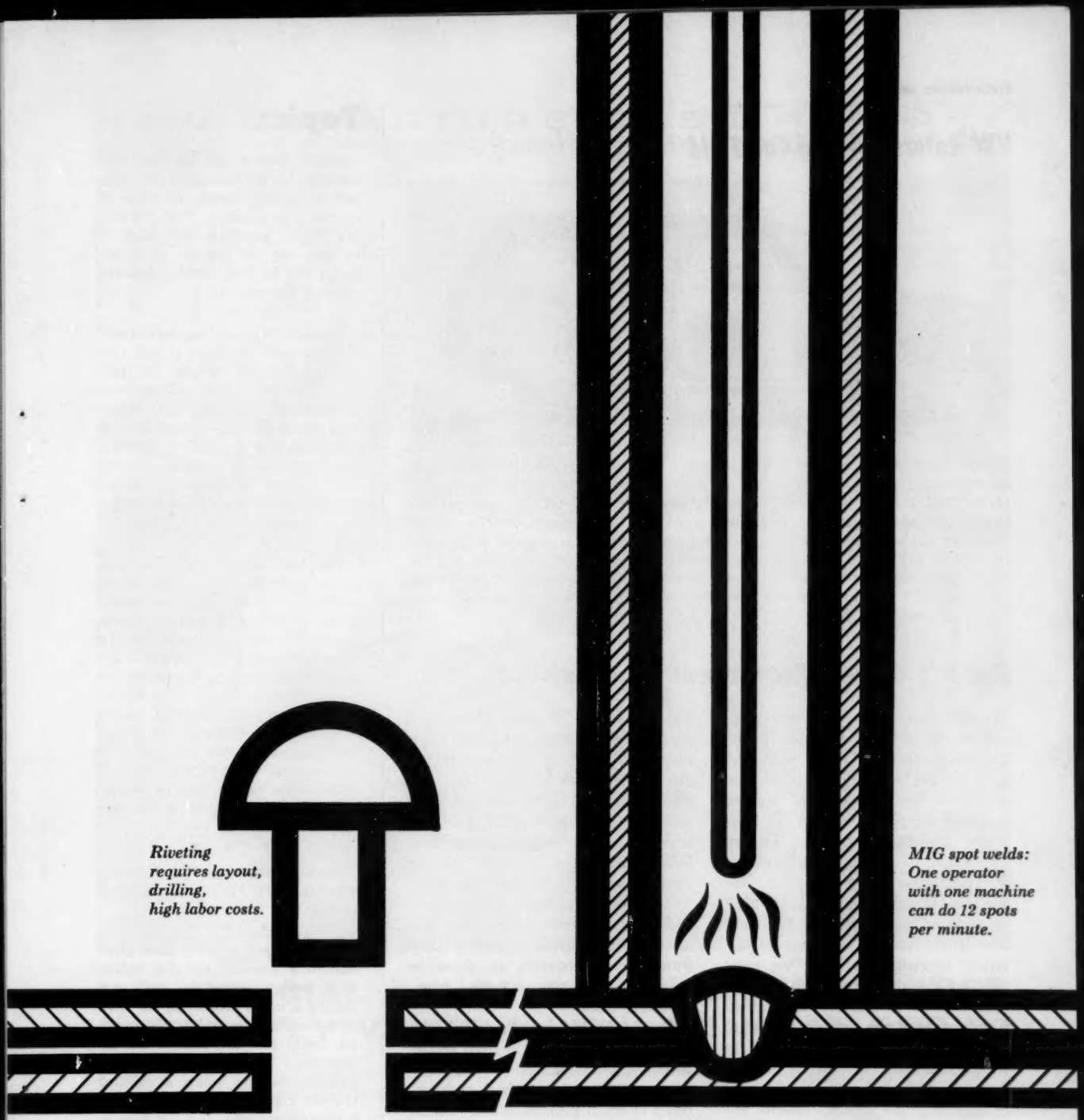
Compared to conventional beryllium bolts, those produced by the SPS process are credited with transverse ductility that triples their double-shear strength. They have higher strength-to-weight properties than similar bolts made of standard steel or titanium. Minimum shear strength is 60,000 psi, and fatigue strength is 45,000 psi.




**Comparison of beryllium bolt** with various high-strength titanium and steel fasteners (left) shows that, on a pound-for-pound basis, the new fastener is strongest. Plot is based on ultimate tensile strengths of the materials; on a shear strength-to-weight basis, beryllium shows a ratio almost twice that of the best steel bolt.

**Various strength-weight ratios** of the bolt are compared (right) with those of standard aircraft titanium and steel shear bolts of the same basic type and configuration (NAS 464). Each ratio is obtained by dividing the actual (typical) physical property by relative weight of material.





*Riveting requires layout, drilling, high labor costs.*

*MIG spot welds: One operator with one machine can do 12 spots per minute.*

**6¢** **3¢**

## How? Ask Olin:

Olin Aluminum Research has now adapted the MIG welding process for spot welding aluminum; overcoming the old problem of inconsistent results. Where properly designed joints are used, the strength of MIG spot welds is as high as or higher than those of rivets or resistance spot welds, at about half the cost of riveting. No matter what you fabricate — aluminum truck trailers, boats, building products, or the like, Olin Aluminum's technical service may be able to help you adapt their MIG spot welding technique. If you're interested in the higher production rate, decreased labor cost and low equipment investment that makes MIG spot welding 50 to 100 per cent cheaper than riveting, call your local Olin Aluminum Sales Office and our expert metallurgical and technical service is quickly on the way.

**Olin**
**ALUMINUM®**
400 PARK AVE., NEW YORK 22, NEW YORK

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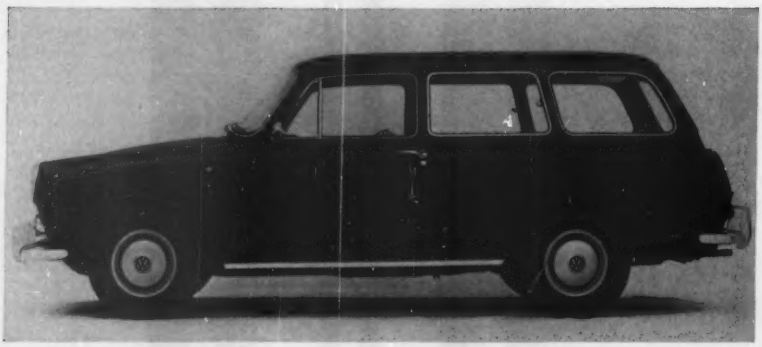
## VW Enters the Big-Car Field



**Station wagons and sedans** in Volkswagen's long-awaited VW-1500 series will be introduced at the International Auto Fair in Frankfort, Germany next August. Larger and stronger than the "classic" Volkswagen, they will be powered by newly designed pancake engines having piston displacements of 91.5 cu in. The new engines are so compact that the sedans will have a trunk in the rear as well as one in the front. As in the smaller VW, the 1500's four-cycle engine, transmission, and differential—mounted as a package—will be easy to remove for servicing. Production of the older-style Volkswagens will continue.

## Doctor's Degree—Requirement for Creativity?

WASHINGTON — "In basic science—and to an increasing extent in engineering—the Ph.D. or Sc.D. degree is the rule rather than the exception for positions of mature responsibility," Dr. Glenn T. Seaborg, chairman, Atomic Energy Commission, stated at the recent Westinghouse Science Talent Research Dinner. The making of a creative scientist involves coaching him in methods of carrying on scientific investigation, and "we must rely on the discipline of our graduate schools to convert the trained intelligence of the undergraduate to the creative intelligence of the research scientist."

In graduate school, Dr. Seaborg continued, "the student learns experimental techniques, how to set up a meaningful experiment, how to extract correct answers from the data he collects, and the importance of letting unexpected results lead to new conclusions and new experiments."

Graduate research makes an enormous change in the doctoral candidate. "At many institutions, the research interests of the teaching scientist are very advanced and are likely to be in a frontier area far beyond the material currently appearing in undergraduate textbooks."

High school and undergraduate training have the same chief purpose: That of presenting the huge output of previous scientists. "When the student gets his bachelor's degree, he should have accurate concepts of the general features of the sciences and be able to relate new information he will acquire in the future to what he has learned." While they are basic, high school and undergraduate study are not an end in themselves—rather they form the prerequisite to three to seven years of graduate and post-graduate work.

Even with his doctor's degree, the scientist may never win high recognition. "One cannot explain why one scientist is recognized and another of equal promise is not." Plain, old-fashioned hard work is not the difference; "the greater effort expected of the scientist seldom is extracted against his will. Scientists are not clock watchers. The large majority work in laboratories where the doors are never locked and where lights frequently burn late into the night. Four major factors go into the make-up of a creative scientist—intelligence, motivation, training, and a willingness to work hard." Recognition comes to the man who possesses the proper mixture of the four at the given time and, in addition, has a certain amount of luck.

## Topics

**Middle sister to the Chevrolet and Corvair,** to be introduced this fall, will be named Corsair, according to rumors from Detroit. The newcomer's 114-in. wheelbase will allow it to nose out the Corvair by 6 in., but it will be 5 in. shorter than the standard Chevy.

• • •

**The new Macdonald** has a farm well equipped with machinery. Latest census figures show that 80 per cent of U. S. farms have tractors—over 5 million of them. In 1940, tractors were found on only 15 per cent of the farms, and the total in use was about 1½ million. Similar increases have occurred in numbers of trucks, harvesters, milking machines, and other farm equipment.

• • •

**Less heat, without more humidity,** is promised by an evaporative air cooler patented by Dr. Peter Schlumbohm of New York. In the cooler, a pair of facing discs revolve, creating a partial vacuum. Evaporation takes place in this vacuum, and cooled air is thrown off the edges of plastic filters through which it passes. Effect of previous evaporative air coolers has been limited to about 5 F and their use limited to dry climates; Dr. Schlumbohm reports that in his experiments he has reduced the temperature 16 degrees.

• • •

**Sentiment dispenser:** A new vending machine offers 160 different greeting cards.

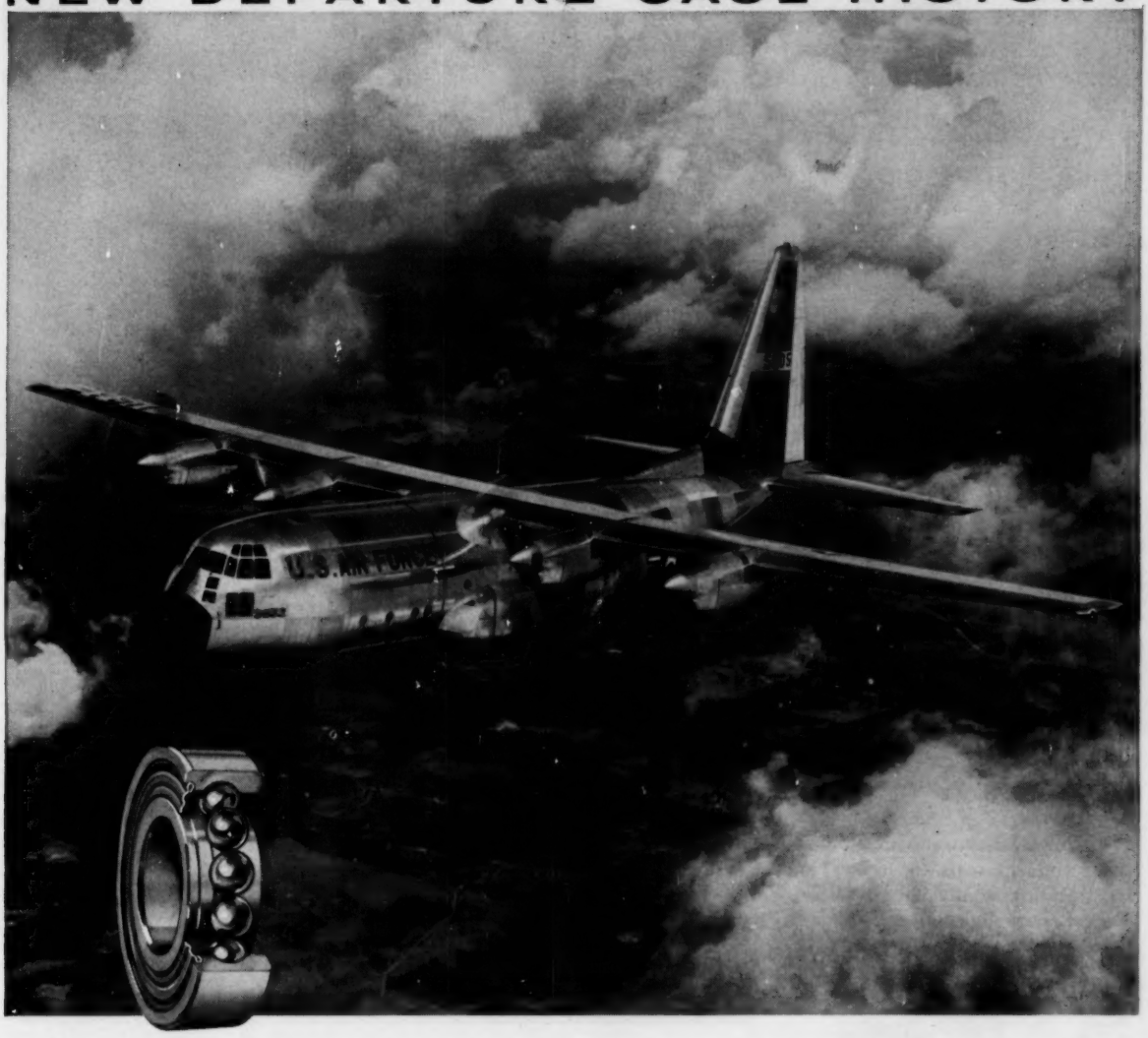
• • •

**Tin cans and a string** have given way to a scientific toy that utilizes solar energy. With the sun's rays striking a mirror located on the front of a Sun Fone transmitter, the operator speaks into the back of the instrument. Voice vibrations become pulsating sunlight which is reflected into the cone of a receiver containing a photoelectric cell. This cell converts the voice-vibrated light into electrical impulses which are heard through earphones connected to the receiver. The Sun Fone Communications system, molded of Bakelite general-purpose styrene, is made by the Hearever Co.

• • •

**A society for the preservation of barbers** may have to be formed if a new invention for hair-cutting finds public favor. A device patented by Harry Morgan of Youngstown, Ohio, holds the head in place and clips the hair, tapering from top to sides. Various templates enable the gadget to produce crew cuts, flat tops, etc.; however, it cannot discuss sports or argue politics.

# NEW DEPARTURE CASE HISTORY



## N/D SPECIAL ALLOY BALL BEARINGS KEEP BUTTERFLY VALVE MODULATING AT 900°F.!

**PROBLEM:** Require highly heat-resistant ball bearings for butterfly valve which modulates 900° F. hot air blast in turbine air bleed. Despite radial loads up to 300 lbs., shaft must turn effortlessly through 65°.

**SOLUTION:** New Departure Sales Engineers, cooperating with Stratos, manufacturer of the constant speed auxiliary power turbine, recommended N/D's special aircraft ball bearing of cast cobalt base alloy for this critical application. These bearings were selected for their ability to withstand extremely high temperatures without deterioration.

Extensive testing proved that the bearings in this N/D equipped modulating system, currently used on the Lockheed Hercules C-130A military transport, operate at required standards of performance and reliability . . . and without lubrication! What's more, maximum turbine speed variation, produced by full throttle, is completely corrected in 1.5 frictionless seconds.

If your aircraft accessory designs require bearings that operate efficiently at unusually high temperatures and speeds, invite a N/D Sales Engineer to participate in your early design discussions. For additional information call or write New Departure Division, General Motors Corporation, Bristol, Conn.

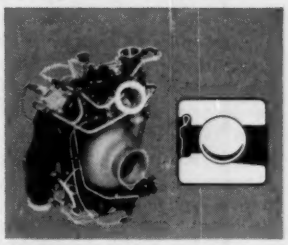
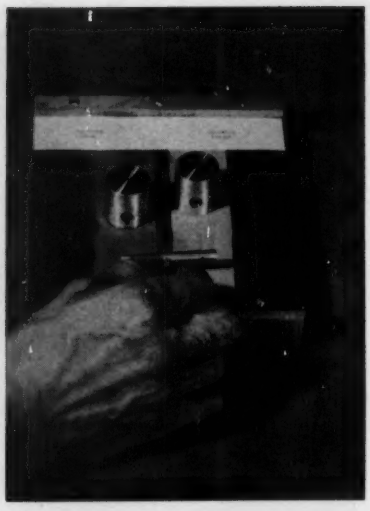


Photo: Courtesy Stratos Division. Fairchild Engine and Airplane Corp.

Auxiliary power turbine equipped with cobalt base alloy N/D ball bearings which operate successfully at high temperature without lubricant protection!

# NEW DEPARTURE

BALL BEARINGS · PROVED RELIABILITY YOU CAN BUILD AROUND

**Wetting angle** of water on natural rubber measured 78 degrees; on slippery rubber, the angle was 101 degrees (above). Contact angle and coefficient of friction are related, since both are functions of the free energy of a surface. Smaller friction coefficient again shows up (right) in the smaller spring deflection. The spring pulling the weight over slippery rubber is almost the same length as when unstressed.

## Slippery Rubber Needs No Lubricant

WALLINGFORD, CONN. — Slippery to the touch but highly elastic, a new material now being developed by Quantum Inc. takes the rub out of dynamic seals. The elastomer, combining the lubricity of Teflon with the resilience of natural rubber, will reduce wear—chief cause of seal failure—in a host of applications:

- O-rings, Chevron seals, U-packings, and lip seals for rotary and reciprocating shafts
- Low-speed, light-duty bearings for shafts and actuator linkages
- Lining material for ball and plug valves
- Nonstick static seals
- Molded and extruded strip shapes for sliding-panel closures

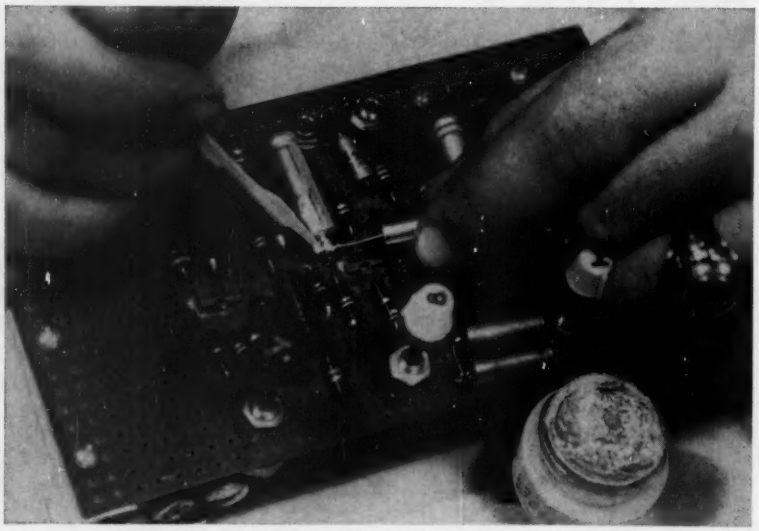
Development work is in an early stage, and much more research remains to be done on specific applications. However, Dr. C. M. Doede, Quantum's president, expects that the service life of many types of rubber seals in mechanical products will be greatly extended. The material can function for long periods of time without any applied lubrication.

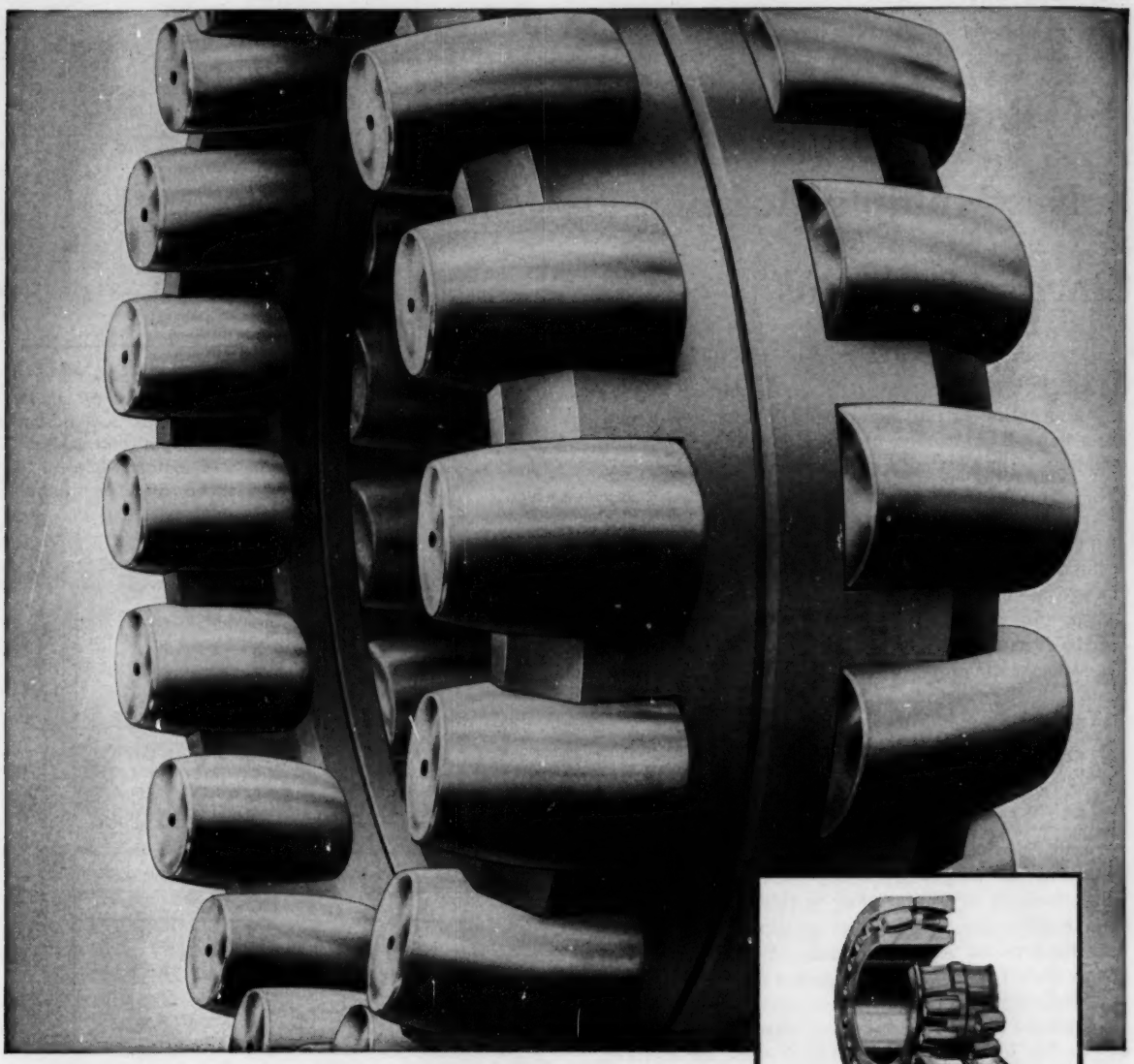
Lubricity data (obtained by measuring contact angles between water droplets and a sample) were determined as 101 degrees on the new elastomer, 78 degrees on the natural-rubber control, and 104 degrees (literature value) on Teflon. Large contact angles are a characteristic of low-friction materials. Other measurements show the friction coefficient of slippery rubber is 10 per cent that of natural rubber under static load, less than 10 per cent under dynamic load.

Although all slippery-rubber samples have been produced from the same chemical process (from natural rubber), Dr. Doede believes several other treatments will work equally well. It is possible, he continues, that the tailoring of self-lubricating elastomers for specific applications will soon become feasible.

## Conductive Epoxy "Solders" at Room Temperature

**Stronger than metal solders,** a new epoxy bonds electrical circuits together without mess or heat. Developed by Epoxy Products Inc., division of Joseph Waldman & Sons, Irvington, N. J., the conducting epoxy (resistivity is less than 0.01 ohm-cm) comes in two forms: A one-component heat-curing (at 125 C) paste, and a two-component paste that cures at room temperature. According to EPI, both are ideal for use on printed-circuit boards where soldering temperatures might damage heat-sensitive parts. In addition, since there is no flux or residue, the epoxy cannot contaminate electronic components. Bond strength is high, even when the epoxy is used for conductive bonds between dissimilar metals. Shear strength of a steel-to-steel bond was measured as 3200 psi.







**Superior design features of TORRINGTON SPHERICAL ROLLER BEARINGS**

- integral guide flange for roller stability
- asymmetrical rollers seek flange for positive guidance
- electronically matched rollers
- size-stabilized races
- fully machined land-riding bronze cages
- controlled internal clearances
- even load distribution
- inherent self-alignment
- long service life

# "Caged" for Longer Life!

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Circle 410 on Page 19

# A-C Power Package Solves Multiple-Motor Starting Problems

VARYING the frequency of the supply driving an alternating-current motor offers a flexible and stepless means of controlling its speed. In the single-motor installation, speed accuracy is as good as frequency, and motor starting makes no unusual demands on the supply. However, designers of multi-motor applications (e.g., in conveyors) have found that the relatively poor regulation (voltage vs. load) of conventional separately excited alternators—often used as variable-frequency sources—may introduce starting problems that must be reckoned with. Unless the alternator is considerably oversize (with respect to the steady-state demand), motors that are already running will pull out of step or stall when another motor is thrown on the line.

A new packaged variable-frequency power supply—called Vari-Cycle—has been designed to circumvent the multi-motor starting problem. According to the developer, Reliance Electric & Engineering Co., Cleveland, the unit will hold ±5 per cent voltage regulation, while supplying an output frequency adjustable through a range from 20 to 100 cps. Key to this performance is a unique alternator that employs no slip rings or brushes, and requires no separate exciter. Fast alternator recovery time (up to 12 times that of a conventional unit, says Reliance), coupled with the precise voltage regulation, allows any combination of motors to be started across the line while any other motors are running.

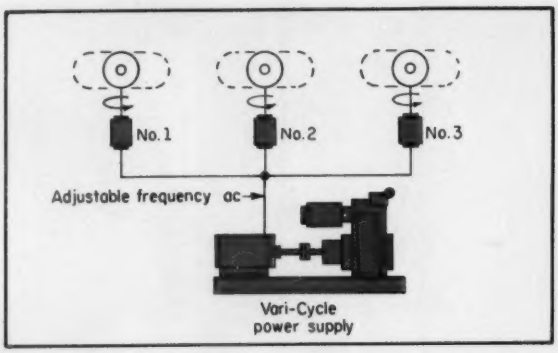
### For a Built-In Exciter: Rotating Rectifiers

The Vari-Cycle system constitutes a three-unit package: A squirrel-cage or synchronous-reluctance drive motor; a mechanical speed changer (Reeves Motodrive); and the brushless alternator. Varying the ratio of the speed changer—manually or by remote control—changes output frequency through the design range.

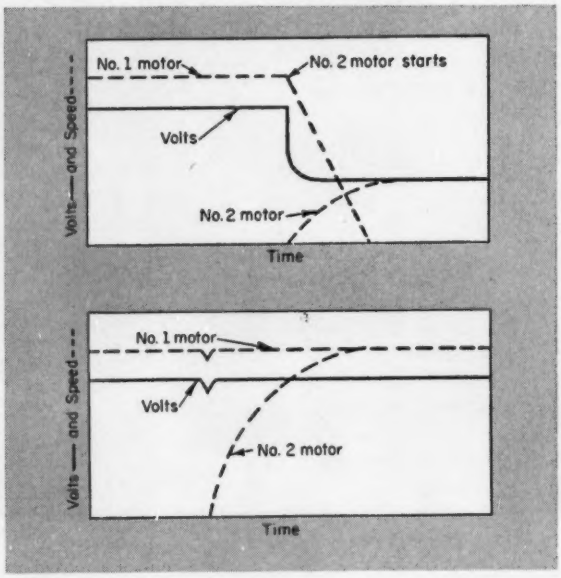
Reliance eliminated slip rings and brushes in the three-phase generator by building alternator and exciter rotors on a common shaft. Output of the exciter rotor—rectified by rotating silicon units—is applied through direct connection to the alternator field (also rotating). All connections between exciter and alternator stator windings are made internally within the common housing.

Response time of the integral excitation system is very fast since the exciter carries an alternating voltage proportional to the load current. Any increase in load current causes an immediate increase in exciter output, which is then rectified and applied to the alternator field winding.

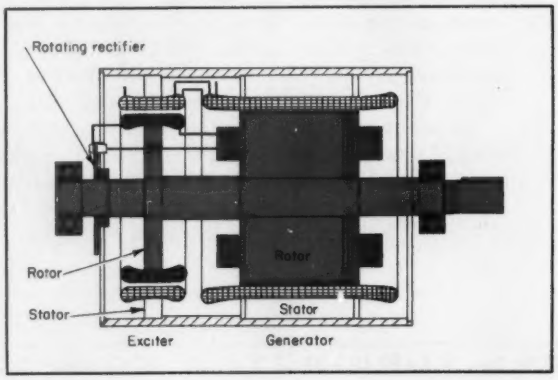
Torque-compensation control—a characteristic desired

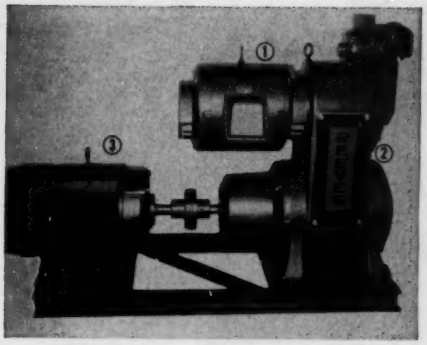



**Synchronized multi-motor conveyor-drives** (above) demand close control of voltage from variable-frequency supply alternators. Vari-Cycle—a packaged source built around an integrally excited alternator with 5 per cent inherent regulation—starts any combination of motors while others are running. The unit offers 5:1 speed range for squirrel-cage and reluctance-synchronous motors.




**Plots compare starting performance** of two-motor drive installation supplied by a conventional alternator (upper graph) and closely regulated Vari-Cycle (lower graph). In each case, No. 1 motor is running when No. 2 is started. Poor regulation of conventional alternator voltage forces first motor to stall when the second is thrown on the line.

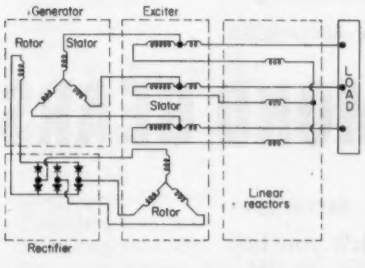





**Supplied as a packaged system** developing 20 to 100 cps output-frequency range, Vari-Cycle comprises: 1. Input motor, 2. Speed changer, 3. Alternator.

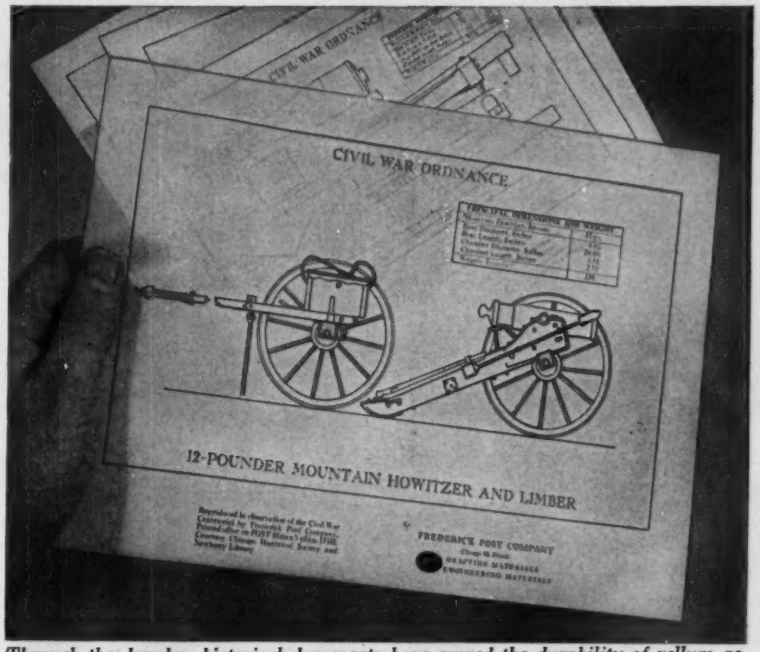
in conveyors where individual motors are tied to a common chain—is offered by a variation of the basic Vari-Cycle. In this alternate form, the exciter stator includes only single-phase power and utilizes two windings. The first winding operates during motor start-up; the second, during normal operation. When the run winding is active, a series-connected variable-ratio transformer is used to adjust alternator output voltage, permitting torque adjustment and load sharing among motors in a chain.

According to Reliance, the close voltage regulation offered by the unit also eliminates need for reduced-voltage starters in installations employing "locked together" reluctance-synchronous motors. Instead, lower cost, across-the-line starters will allow any combination of motors to be started without overloading the alternator.




**Exciter rotor winding** (sketches left and above)—which acts like the secondary of a rotating current transformer—applies rectified voltage to the rotating alternator field. High-level load currents, acting through the exciter stator, raise voltage output of rotor winding. No-load excitation and compounding characteristics are provided by shunt and series exciter-stator coils.

# DRAFTING TRENDS

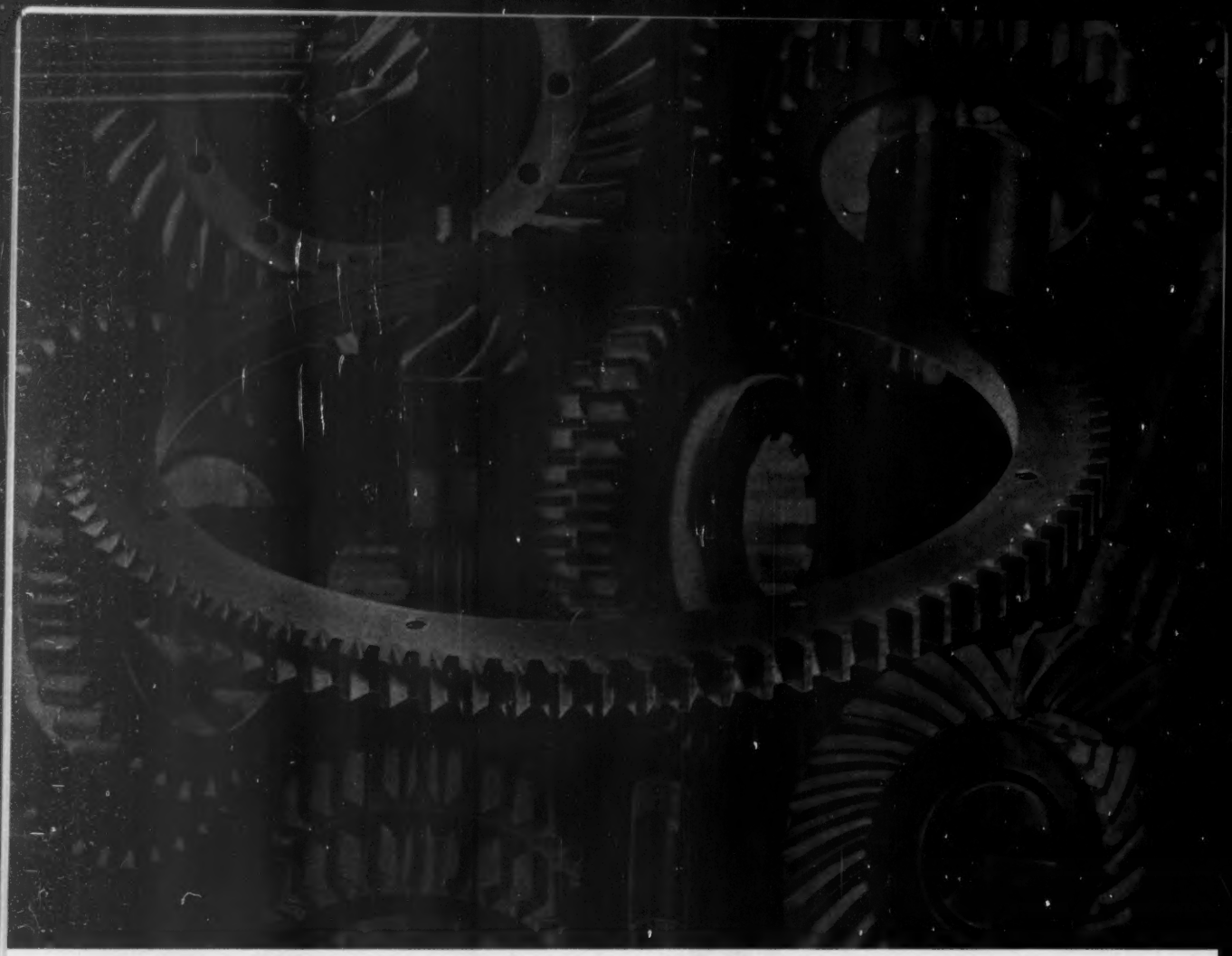



*Through the decades, historical documents have proved the durability of vellum as indicated by the facsimiles of Civil War engineering drawings above, reproduced on* POST *Blutex Tracing Vellum.*





Circle 411 on Page 19



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## SUBJECT INDEX

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## Index to New Parts & Helpful Literature

### BY ITEM NUMBERS

### HELPFUL LITERATURE—descriptions start on page 156



### NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 160

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| 415 | 445 | 475 | 505 | 535 | 565 | 595 | 625 | 655 | 685 | 715 | 745 | 775 | 805 | 835 | 865 |
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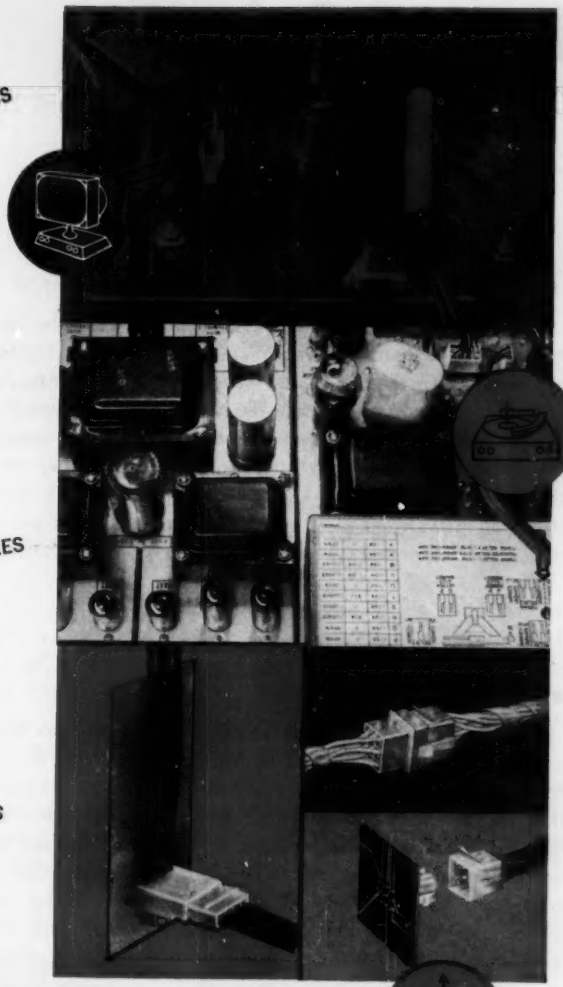

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# NEWS TRENDS

## cars without corrosion

The salt that removes snow from city streets and metal from the undersides of cars can be discouraged from the latter activity by use of high-strength steels in automobiles. Dr. R. B. Mears, assistant vice president—applied research, U. S. Steel Co., reports that atmospheric tests have proved that high-strength, low-alloy steels exhibit superior resistance to corrosion—even if they are not painted. When paint is applied, it lasts much longer than on carbon steel. Two other corrosion-preventive measures suggested by Dr. Mears are the use of hot-dipped galvanized steel sheets for box sections used in automobile construction, and the avoidance of pockets or shelves where dirt and moisture can collect.

## nonexpendable boosters

A 50-mission rocket—possible in the not too distant future—has been compared in "reusability" to commercial and military aircraft by S. K. Hoffman, president of Rocketdyne, a division of North American Aviation Inc., Canoga Park, Calif. Mr. Hoffman told the House Committee on Science and Astronautics that liquid-propellant booster engines in use today can be rerun 50 to 100 times—which means that the same booster can be used for multiple space launchings—for essentially the cost of the propellant, about five cents a pound. Mr. Hoffman believes that the reusability feature will make the realization of space goals dependent upon liquid-propellant and nuclear-rocket engine systems.

## the price of professionals

Experts and consultants hired by Federal departments and agencies on a temporary basis should be paid a maximum of $100 per day, according to the National Society of Professional Engineers. Paul H. Robbins, executive director of NSPE, recently pointed out to House and Senate Appropriations Committees that an apparent trend to reducing rates to $50 or $75 a day might keep the most qualified engineering firms from accepting government work because it would be economically unwise for them to do so.

## planetary travel bureau

Space-flight timetables—for charting flight paths for low-thrust rockets—are being worked out by the Lockheed Missiles and Space Div., under contract to the propulsion laboratory of Wright Air Development Div., Air Research and Development Command. Tables will contain information on speeds, heading, payload, flight times, booster rockets, and available low-thrust rocket engines. An IBM 7090 computer, armed with these data, will be able to select the best time and route for making any trip to the moon or near planets.

## Univac learns a second tongue

Two new electronic converters are as fluent in Japanese as in English. Designed for the Tokyo Electric Power Co. by Digitronics Corp., Albertson, N. Y., the two will call on an alphabet of 96 characters to handle data in both languages. The converters will be used to switch information from perforated paper tape to magnetic tape in TEPC's Univac installation.

## the translation race

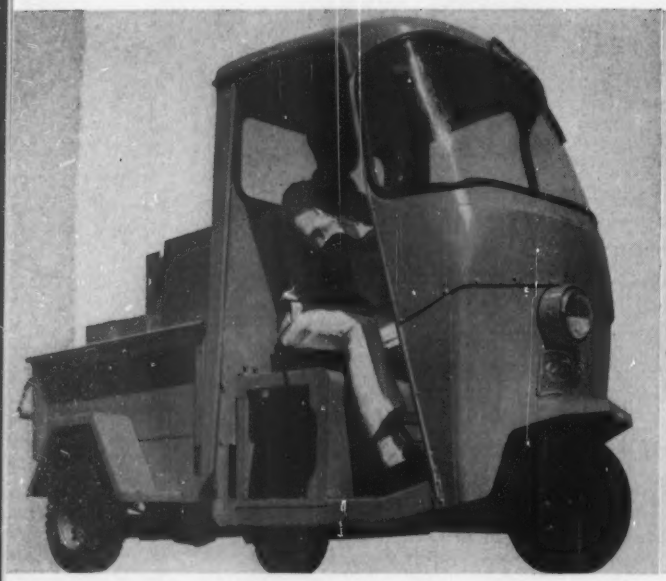
Studying language translation needs for IBM, Planning Research Corp., Los Angeles, learned that requirements for U. S. Intelligence will increase from three to ten times by 1970. In round figures, this forecast means a maximum of 4 billion words per year, or a minimum of over 1 billion. The country's present translation capacity will fall far short of the demand, and effective means of automatic translation are urgently needed, according to PRC. Another source (Gen. James M. Gavin) reports that in the Soviet Union, over 2000 full-time and 20,000 part-time workers abstract and translate technical articles, and deliver them to Russian scientists four to six months after original publication. The best American counterpart system has 1700 part-time workers, and translation takes a year.

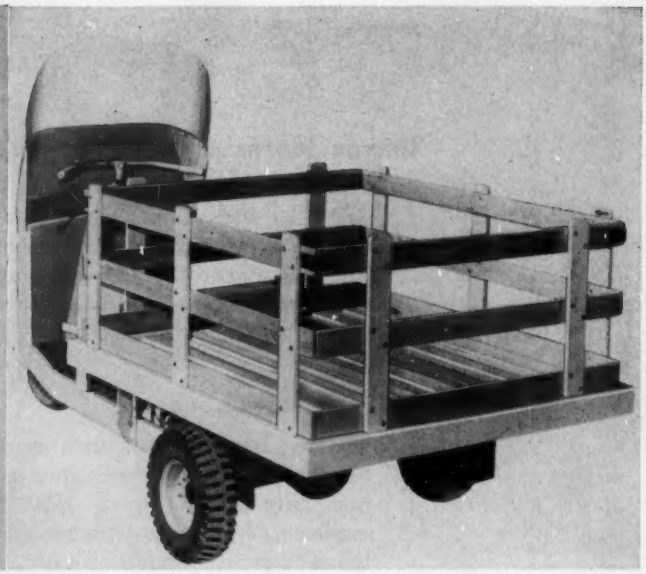
## state of the solid-state art

Future emphasis in military solid-state electronics will be on a basic change in system design, circuit design, and device fabrication—not on development of equipment or better replacements for present conventional electronic components. The final report of an Office of Naval Research study group says that the full impact of the past decade of research on solid-state devices is just beginning to be felt in the design of military equipment. Future development and adoption of microelectronic devices and techniques by the military are expected to have a profound and wide-spread effect on the electronics industry and on equipment and functions.

## reliability by committee

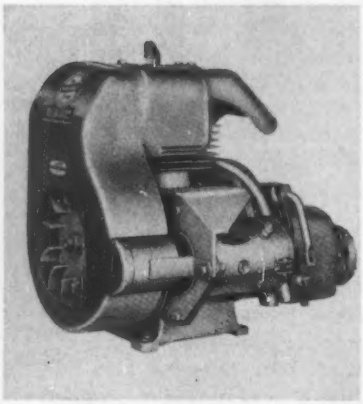
In striving for greater product reliability, industry must first define reliability, then decide how to build it in. This is what Hall Cary, Battelle Institute reliability specialist, told attendees of a recent Society of Automotive Engineers meeting. Mr. Cary said, "Quite simply, a reliable device does what the customer expects it to do." He feels that reliability has not been stressed as a criterion of good engineering practice and suggests that a separate engineering group should specify product requirements. For instance, a committee—composed of engineers, designers, statisticians, and sales managers—could gather information from engineering tests and from usage, then "observe, criticize, instruct, and influence" product design.





# Three-Wheel Transports

## Common Chassis and Power Train Fit a Fleet

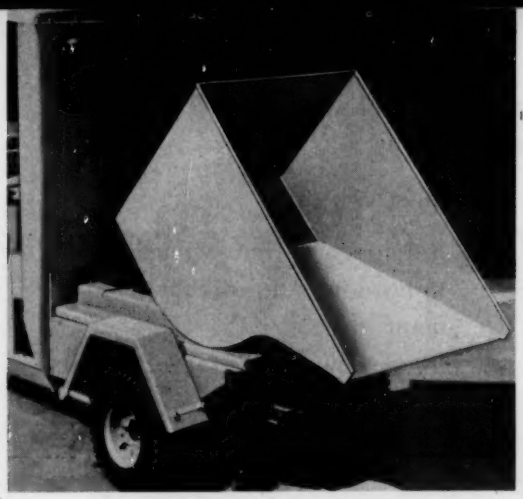


**Speed of 4500 rpm** can be maintained by Truckster's one-cylinder four-stroke engine. It delivers 7.95 hp at 3800 rpm, weighs 76 lb. Displacement is 19.4 cu in.; torque, 13.2 lb-ft at 2600 rpm. Power train includes a constant-mesh transmission, centrifugal clutch.

IN many European countries, small multipurpose vehicles (with from two to four wheels) are probably seen more often on streets and highways than full-scale automobiles. The trend in this country seems also headed in the direction of compactness, although it is extremely doubtful that scooters and three-wheelers will ever replace the conventional first or second car. Instead, a demand is growing rapidly for sub-compact utility vehicles in business and industry.

Outboard Marine Corporation's Cushman Motor Works, a major U. S. supplier of pint-size transports, recently began a major production run of its famous Mailster. In mobilizing the mailman, Cushman engineers relied on their basic vehicle—the Truckster—which has the built-in versatility of a chameleon. Skin deep, the Truckster is easily modified to fit almost any environment; underneath, practically no change is required.

Key to the vehicle's versatility is its unique power chassis. The original Truckster was designed for in-plant use. As such, it required a short wheelbase and narrow tread for high maneuverability. At the same



**Regardless of external configuration, all Truckster bodies are mounted on the same unique power chassis . . .**

time, the vehicle had to be dynamically stable, strong, and lightweight. Weight was particularly critical, since vehicle steering was to be accomplished through handlebars with no ratio advantage. The power-chassis meets all of these objectives. It effectively isolates the weight of the heaviest vehicle components—engine, suspension, and power train. Thus, although gross weight of an average Truckster is 1540 lb . . . carrying a respectable 800-lb payload, plus operator . . . it handles as easily as a motor scooter.

The chassis itself is made from sheet metal, formed into special channel sections for maximum strength and flexibility. Crossmembers of various shapes are strategically located to provide not only increased strength, but mounting points for a wide variety of bodies and other attachments.

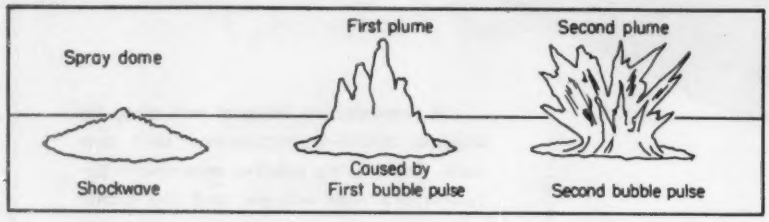
A fiberglass cab with safety-plate wrap-around windshield is Truckster's most popular piece of optional equipment. A pickup box, with fiberglass cover that converts the box into a closed van type body, is also in large demand. An estimated 6500 Trucksters, in assorted body styles, will be produced in 1961.

**. . . it provides an integral mounting for engine, clutch-transmission, and rear axle. There is no relative movement between the rear wheels and the transmission, as in conventional trucks and cars. The chassis was originated to provide a compact vehicle that would use a driveshaft rather than V-belts or chains for power transmission. It has proved better than a conventional configuration for the Truckster-type of vehicle because it permits a short wheelbase, resulting high maneuverability. The power chassis attaches to the main frame through a rubber shear mount at front and a transverse leaf spring at the rear. The shear mount eliminates engine vibration and permits independent movement of wheels, since the power chassis can rotate as well as move in the vertical plane. A torsion-type sway bar is incorporated in the rear suspension to reduce body sway and enhance stability; shock absorbers are optional.**

# Underwater Explosions

**are teaching the Navy how to harden and protect equipment from battle damage. Ideas now being tested will probably apply in dry-land designs where shock and vibration are serious problems.**

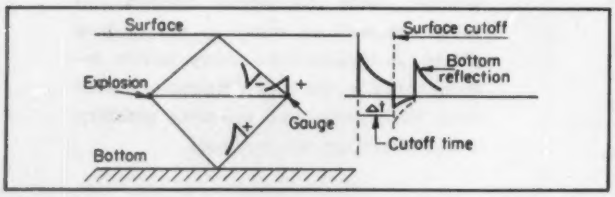
**Underwater chemical explosions** send up a shock wave and a bubble of gas. The bubble expands until its internal pressure is less than that of the surrounding water, then collapses, causing a second shock wave (bubble pulse). Bubble pulses are propagated each time the bubble collapses on its way to the surface.

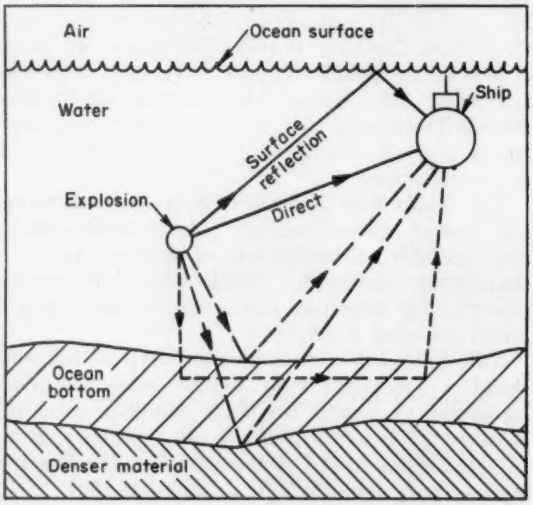


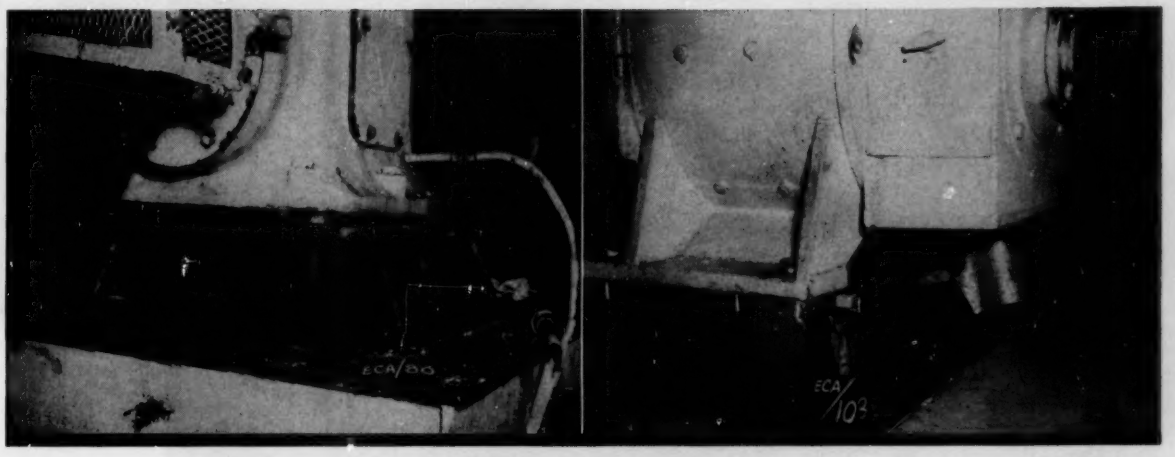

FORRESTAL-CLASS aircraft carriers can survive explosive punches that would have sunk World War II battleships. They're tough, partially because the Navy has beefed them up with thicker structural cross sections. But heavier structures aren't the complete answer. Equipment and systems for today's warships are designed to ride with a blow, absorbing its energy without damage.

The beginning of shock testing of shipboard equipment coincided with the development of gages and recording devices having the required sensitivity, response, capacity, and ruggedness for short-duration transient phenomena. Today, the Navy runs a full-scale underwater explosions testing laboratory at Norfolk Naval Shipyard, Portsmouth, Va. Theoretical and experimental work on design for maximum damage resistance is showing the Navy how to reject weapon energy without in-

**Shock waves** follow many paths in moving from the explosion center to a ship (submarine in the example, right). Surface-reflected wave, opposite in sign and lagging in phase, acts to cut off the direct wave (below), but pulse reflected from the bottom again reinforces initial shock. Normally, the direct wave is felt first, but the ground shock may beat it to the target, due to a possible higher wave velocity in the ocean bottom.





**Shock damage** (such as that suffered by the steam-driven blower, left, and the ship-service generator, right) can be severe even though the ship's structure is essentially unharmed. To improve resistance of such equipment, the Navy is studying shock motions, analyzing modes of failure, and developing new techniques for testing systems and components.

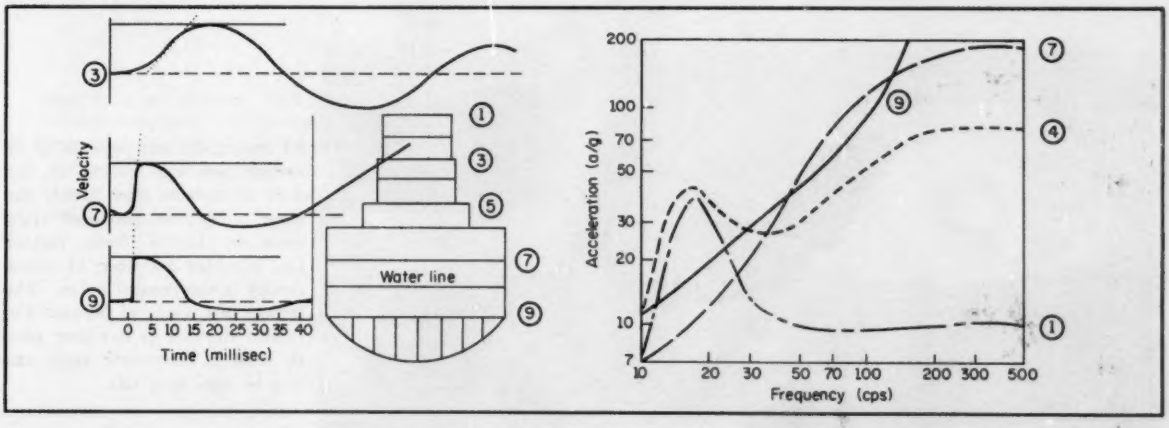
capacitating the ship. Obviously, damage resistance cannot be built in at the expense of weight and space vital for other functions.

Battle damage can be caused by many weapons—both chemical and nuclear. When underwater shocks are transmitted to a ship, a wide variety of motions can result. The initial pulse will start the ship vibrating; later pulses may reinforce or reduce amplitudes of particular modes. Accelerations of several hundred g's are experienced on various decks, and these accelerations produce much of the equipment damage—particularly to brittle materials.

Energy release from contact explosions is so great that defensive efforts are aimed at containing, as well as partially rejecting, the blast. Absorption through plastic deformation of materials, and absorption-rejection through air compression are important techniques.

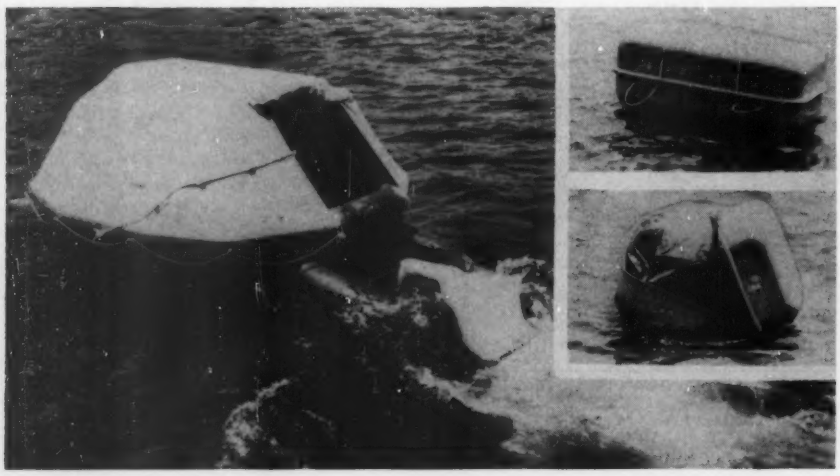
Rejection of energy through shock resistance involves "hardening" shock-sensitive components. According to the Navy, this is best accomplished at the design stage. The technique often leads to significant improvements at little cost when careful thought is given to materials, mountings, clearance between equipment and structures, etc.

Newest method of protecting equipment that cannot be hardened calls for shock mounts to attenuate vibratory motion. Theories that estimate the motion transmitted to equipment have been developed and successfully applied. Experiments with various energy-absorbing materials and new ways of mounting machinery and other vital equipment are also showing Navy how breakable equipment can be most effectively protected.

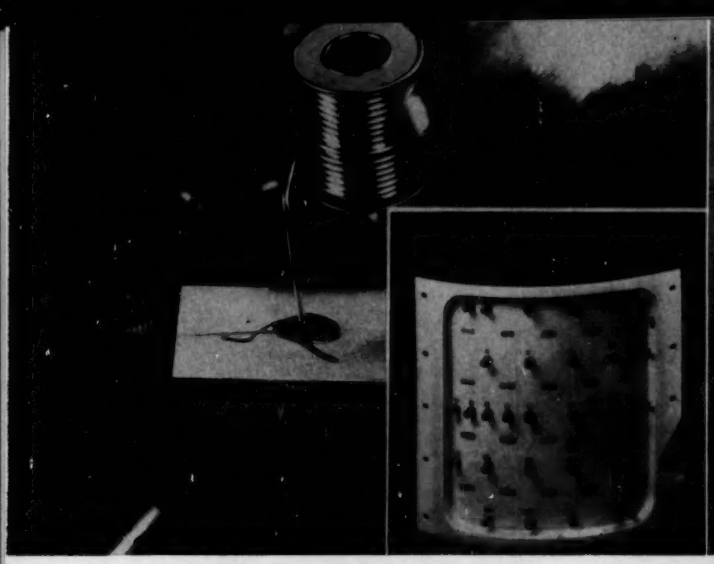



**When a shock wave** hits a ship, many motions result. At the ship's bottom, velocity peaks in about one millisecond (left). On higher decks, speeds pick up and die out slowly. Shock spectra (right) show the response of mechanical systems to shock motion. Accelerations at high frequencies (especially near the bottom) can get as high as 500 g.

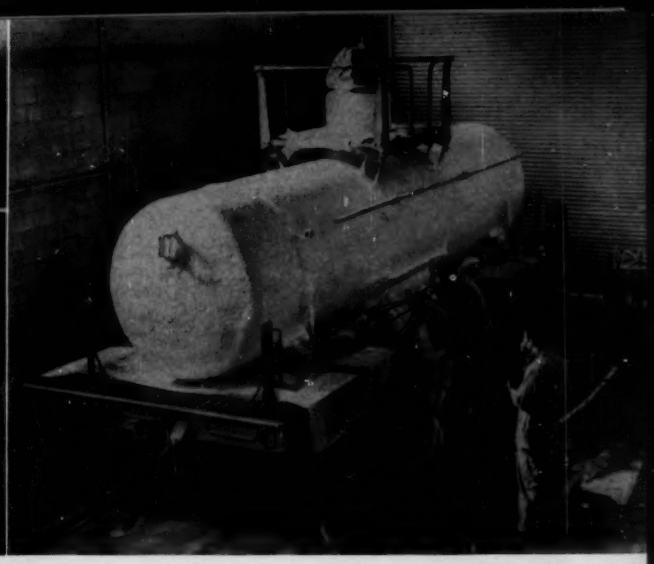

Operational readiness of an ICBM—or any other complex weapon system—is tested quickly by an automatic electronic analyzer built by Hughes Aircraft Co., Culver City, Calif. Going through a system checklist, D-PAT (Drum-Programmed Automatic Tester) spots any component or assembly that is faulty. It projects a 35-mm slide to show a malfunctioning circuit or system and points a red arrow at the part that needs replacing. D-PAT can also predict the life expectancy of components.



An instant life raft pops out of its storage case and inflates in less than 30 seconds after hitting the water. The ten-passenger raft, made by United States Rubber Co., is rubber and fiber; its yellow canopy is vinyl-coated nylon. The storage case, made of buoyant Expanded Royalite (a five-layer plastic with a honeycomb core) can also be used as a raft.



Temperature and shock resistance and light weight were requirements met by this terminal board built of glass-cloth laminates bonded with silicone resins made by Dow Corning Corp., Midland, Mich. The insulating board, specified by Lear Inc. for rocket and missile guidance systems, will withstand soldering temperatures (450 to 500 F) without loosening of terminals. It can also stand shock to 30 g. The terminal boards are made by Silicone Insulation Inc., Bronx, N. Y.



Sprayed-on foam insulates tank cars effectively and allows considerable weight savings. On a conventional tank car, the insulation and steel outer jacket combination weighs about 6 lb per sq ft; this rigid urethane foam covering weighs 1 lb per sq ft, or 3500 lb less on a 4000-gal tank shell. National Aniline Div. of Allied Chemical Corp., which is testing the new insulation, also points out that it will not rust or corrode, and that it is easily repairable.

ENGINEERING NEWS

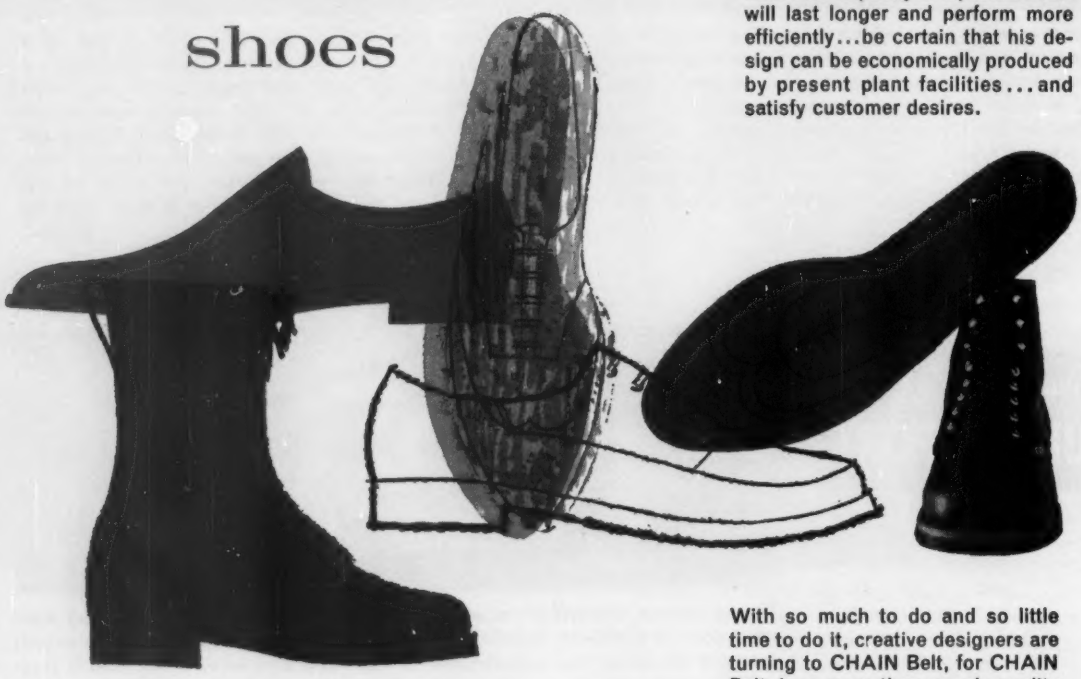
# PICTURE REPORT

The top goes up automatically to admit passengers (and, incidentally, the weather) when either door of Chrysler's Turboflight dream car is opened. Complementing the aircraft styling of the canopy top, a deceleration air flap—suspended between two stability struts—pivots upward into the air stream when brakes are applied. The Turboflight's powerplant is a 140-hp regenerative gas-turbine engine.


Hydrofoils go Oriental: This 70-passenger, Swiss-built PT-20 boat was recently put into service in Yokohama. Powered by a supercharged diesel engine, the 21.5-ton craft can attain a speed of 40 knots.

TO THE CREATIVE DESIGNER...

# how many shoes must you fill?



Today the design engineer must be more than a competent designer! He must wear the shoes of top management, purchasing, production, sales, service *and* the customer.

He must design for lower cost, higher profit..,include more sales features...specify components that will last longer and perform more efficiently...be certain that his design can be economically produced by present plant facilities... and satisfy customer desires.

With so much to do and so little time to do it, creative designers are turning to CHAIN Belt, for CHAIN Belt does more than supply quality products. We provide unequaled service to help design engineers select and apply the proper Rex Chains, Sprockets and Couplings to satisfy his needs.

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Circle 414 on Page 19

# High-Damp Laminate Tames Circuit-Board Vibration

**Ordinary printed-circuit boards, with their fragile components, are prime candidates for destruction under many dynamic conditions . . .**

. . . environmental conditions in jet aircraft and missiles, for example, are particularly conducive to circuit-board failure. The top disturbing frequency in jet specifications is set at 500 cps (it used to be 50 cps). In missiles, excitations may run as high as 5000 cps.

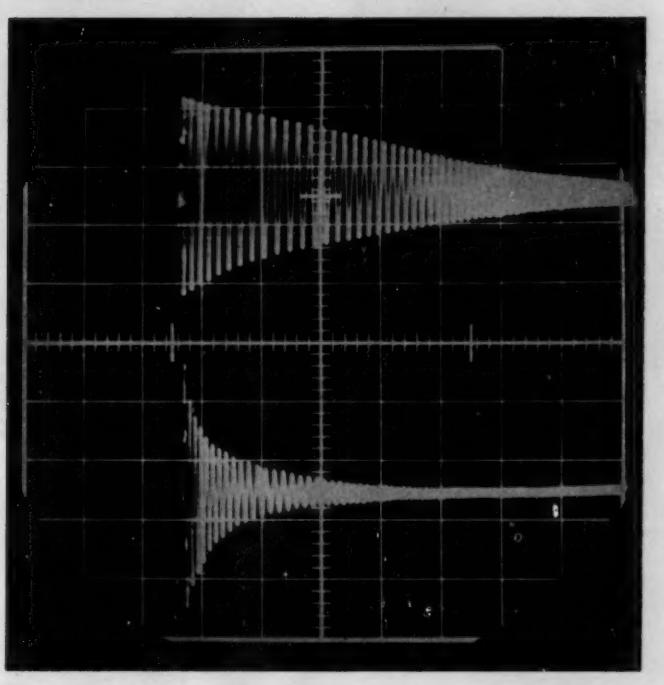
The nature of vibration stimuli can be exceedingly complex. In jets and liquid-fuel missiles, random disturbances created by the exhaust blast are manifested as acoustic energy which is transmitted through the structure and into areas containing sensitive components. In solid-fuel missiles a sinusoidal disturbance, created by resonant burning of the fuel, is superimposed on the random excitations. In addition, superimposed sustained accelerations ranging to 25 g are present.

When resonant response occurs in the ordinary circuit board, one of two things usually happens:

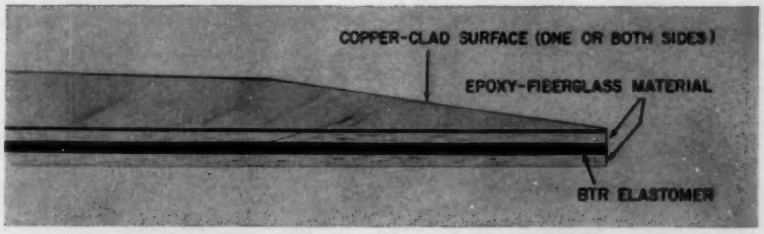
- Oscillation of the board exceeds the alloted space envelope. The board strikes adjacent structures, causing damage and malfunction.
- Energy transmitted through the board may exceed g-levels which the components or attaching material can withstand.

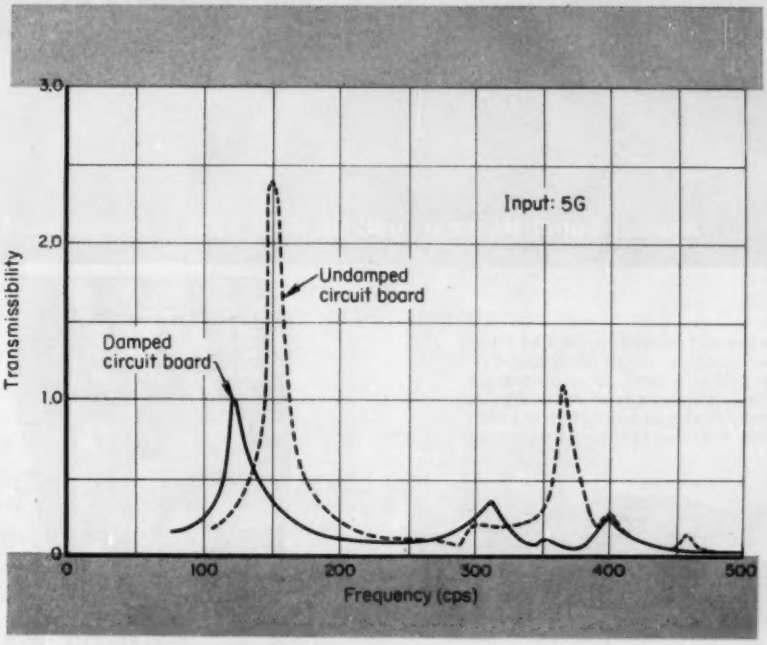
A radically new material, developed by Lord Manufacturing Co., Erie, Pa., effectively solves the cir-

(*Please turn to Page 34*)



**Typical decay-rate traces** indicate radically improved damping characteristics of Dyna-damp board (lower trace) as compared to conventional undamped material. Cross section (below) shows laminated construction of Dyna-damp, with special BTR (broad temperature range) elastomer bonded between fiberglass layers.

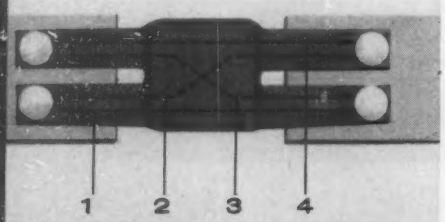


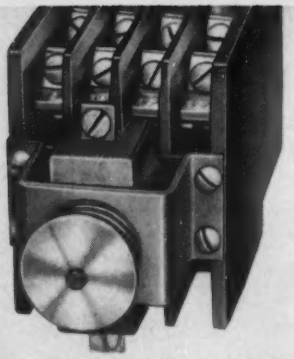




**Transmissibility** of Dyna-damp under resonant conditions is from 50 to about 70 per cent less than the transmissibility exhibited by undamped material.

**Another Cutler-Hammer first!** Up to 24 poles in an area less than the size of a dollar bill.

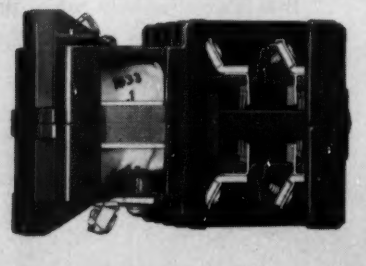
**New contact reliability.** Parallel bifurcated contacts, which allow four current paths instead of one, provide infinitely greater circuit reliability . . . liberally designed so any current path carries full relay rating.



**At last! "Mechanical memory" latch** as reliable as the relay itself! No adjustment ever needed. Add latch at any time.

**New simplified design!** Cutaway view shows basic simplicity. Coil vacuum impregnated to resist damage from humidity, vibration, electrical stress. Terminals can be screw or spade type.




# Space savingest relay you've ever seen: New Cutler-Hammer "Compact 300"

*Versatile 300 V. control relay is so reliable it's permanently sealed!*

Here is the best answer yet to the need for an extremely reliable, small-size 300 V, 6 amp., industrial relay — the new "Compact 300" from Cutler-Hammer.

Every detail known that affects relay reliability has been improved in the "Compact 300." Bifurcated contacts which make possible *four* current paths rather than one, add millions of operations to the "Compact 300's" electrical reliability.

In fact, we're so confident of its electromechanical reliability, we permanently enclose the "Compact 300." And, if it should be damaged by a fault current, you throw it away and replace it with a new one. Its low price makes this an economical, practical maintenance procedure.

Now think of the space you can save with the "Compact 300." It controls up to eight circuits in panel space only 2″ wide by 2¾″ high. 2, 3, 4, 6 and 8 poles with any combination of N.O. or N.C. contacts are available, of course.

At any time, you can add "mechanical memory" latch with a life equal to the life of the relay. No adjustments are ever necessary. Contact your Cutler-Hammer distributor for details on the "Compact 300" or send for Pub. ED- LO-79-E243.

**What's new at Cutler-Hammer?** New, better products, like the 300 V. relay are coming steadily from our new, expanded plant facilities. We're ready now to help you take care of the great industrial growth of the future. If you are planning ahead and need electrical control assistance, contact the nearest Cutler-Hammer sales office.

*WHAT'S NEW? ASK...*

**CUTLER-HAMMER**

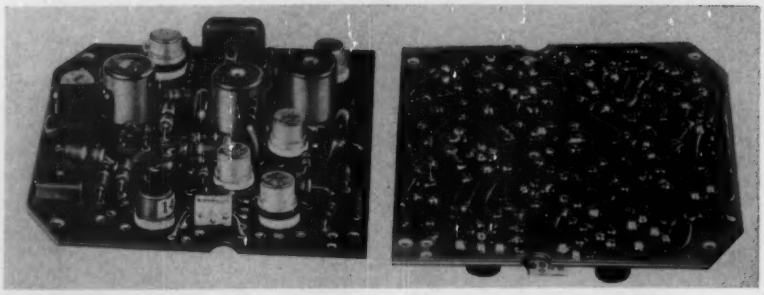

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

Circle 415 on Page 19

(*Continued from Page* 31)

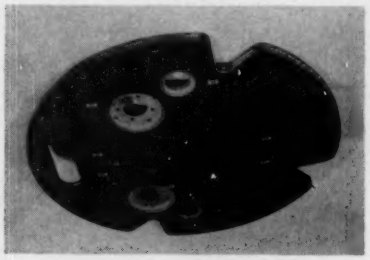
cuit-board vibration problem. It converts vibratory energy into shear strains which are dissipated in an elastomeric layer bonded between elements of epoxy-fiberglass laminate.

The damping layer is a special form of Lord's BTR (Broad Temperature Range) elastomer, a highly damped material which operates at −65 to 250 F, resists a variety of environmental extremes, and adapts to normal processing methods. These properties are expected to enhance design freedom and aid miniaturization in high-density electronic packaging. The designer need not worry about structural response characteristics or local circuit-board resonances. More sensitive components, perhaps smaller and lighter than previous designs, can be used and located to best advantage.



**Highly damped printed-circuit board** (above) and electronic chassis for an ICBM nose cone (below) are typical applications of Dyna-damp. During extensive tests, the material has successfully resisted processing materials and temperatures used in preparing, etching, and soldering printed circuitry.

According to Lord spokesmen, fabrication techniques used with standard boards can be employed with Dyna-damp boards. Where double-sided boards are concerned, ferrules can be used in the lead holes. Typical processing procedures have caused no significant performance degradation.



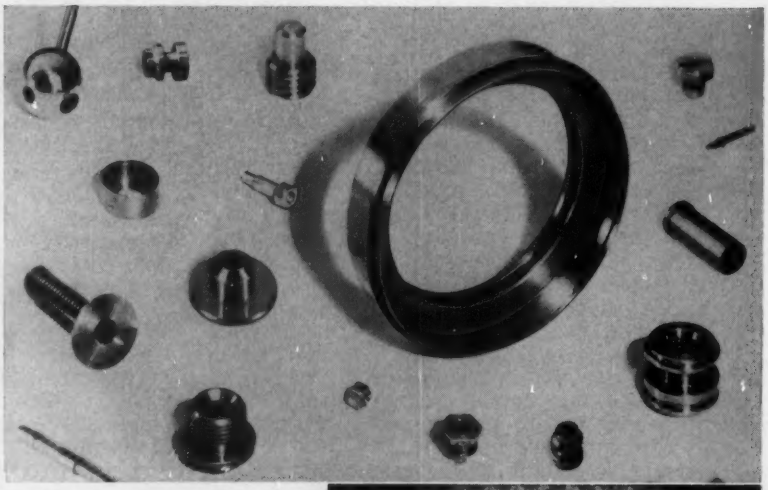
## Free-Machining Stainless Boasts Low-Sulfur Content

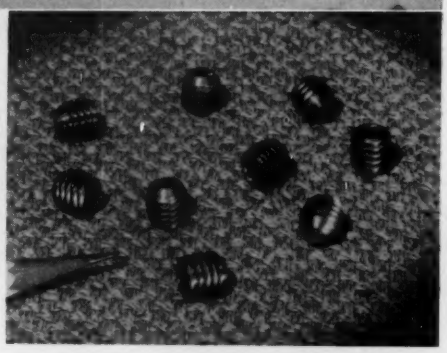
BRIDGEVILLE, PA.—A new free-machining chromium-nickel stainless steel, designated Uniloy 303MA, has been announced by Universal-Cyclops Steel Corp. Compared with regular free-machining AISI Type 303, the new stainless is credited with these advantages:

- Increased output of machined parts
- Better tool life
- Improved finish
- Improved corrosion resistance
- Improved resistance to longitudinal splitting

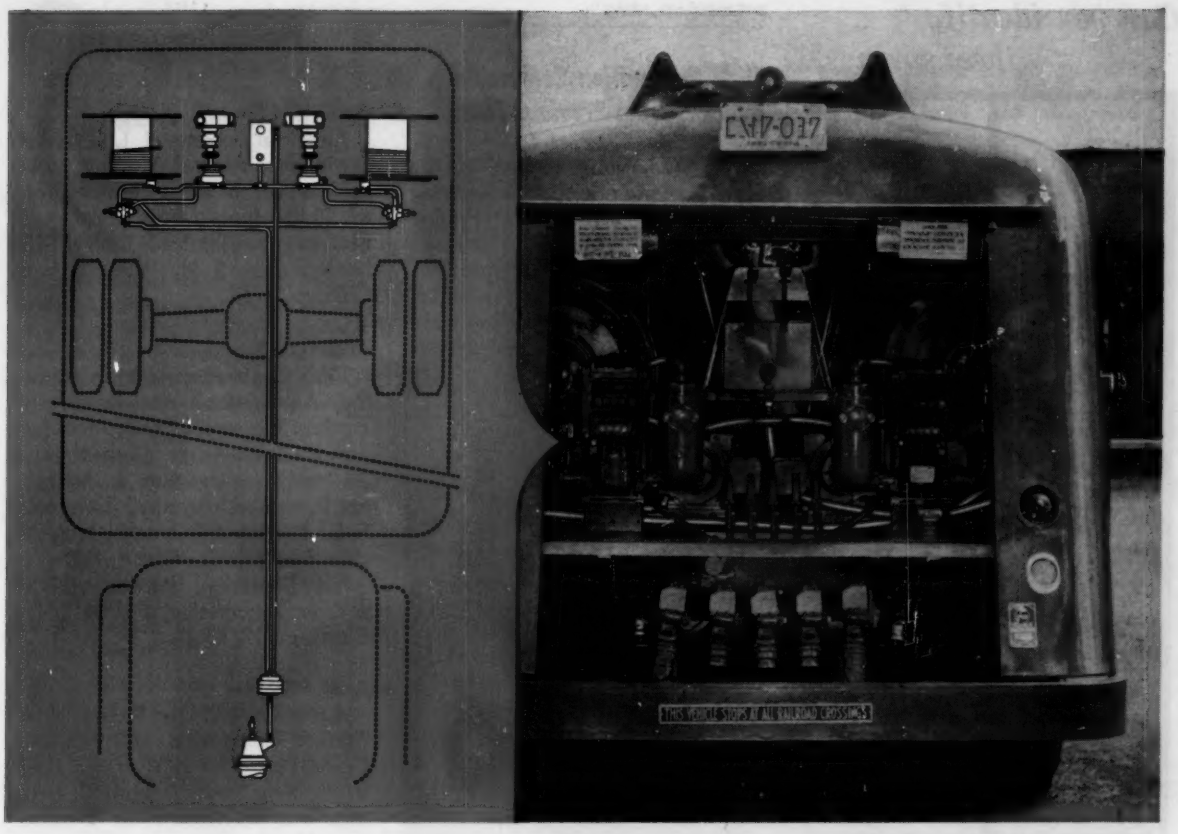
Key to the improved performance is in the analysis, says the developer. In Uniloy, a combination of aluminum and sulphur additives (for better machinability) makes possible reduction in sulphur content to about one-half the amount normally contained in Type 303.

| | 303MA | 303 |
|---|---|---|
| Carbon | 0.10 | 0.10 |
| Manganese | 1.50 | 1.50 |
| Silicon | 0.50 | 0.50 |
| Sulphur | 0.13 | 0.25 |
| Chromium | 18.00 | 18.00 |
| Nickel | 9.25 | 9.00 |
| Molybdenum | 0.50 | 0.50 |
| Aluminum | 0.70 | — |





**Production-lot test runs** for a variety of screw-machine parts (above) demonstrated that Uniloy 303MA can be machined up to 50 per cent faster than regular Type 303. Low level of nonmetallic inclusions (following from low sulphur content) permits thread rolling with good surface finish (right). Uniloy is stocked in all popular bar sizes and forms.



# Ardmore Products relies on Gates Hose for long, dependable service of hydraulic systems

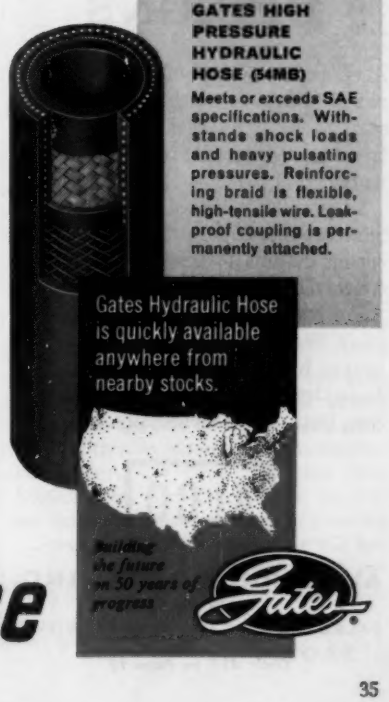
Gates Hydraulic Hose is standard equipment on hydraulic systems made by Ardmore Products, Northbrook, Illinois. These systems are used on tank trucks for pumping petroleum products and for power drives for hose reels.

The Ardmore Hydraulic Drive System is considered explosion-proof . . . is easy to install . . . and is virtually maintenance-free. All connections are made with Gates Hydraulic Hose.

Mr. Edward J. Doyle, Jr., Ardmore General Manager, says, "We use Gates hose to assure the dependability and quality of our product. Furthermore, Gates offers the best in service and in technical assistance."

**Ask for Gates technical aid in designing hydraulic systems.**

The Gates Fieldman located near you is a fully-qualified hydraulic hose expert. He can give you valuable assistance in designing hydraulic hose systems. Ask him for Gates Hydraulic Hose Assemblies booklet, IH43.




**The Gates Rubber Company**, Denver, Colorado

BP 32

# Gates Hydraulic Hose

## Fifth Automation Conference Benefits from Previous Four

LAFAYETTE, IND.—Program of the Fifth Conference on Manufacturing Automation, to be held at Purdue University April 17-19, is based on interests expressed and questions asked during the conferences which were held in 1957-60. The four main areas of automation technology will be covered:

- Organization and Costs
- The Process
- Handling in Process
- Control of Operations

Sixteen papers will be presented during five sessions; there will be discussion periods each day; and luncheon and banquet speakers will discuss automation informally.

The conference is sponsored by Purdue and *Automation;* information is available from K. E. Glancy, Div. of Adult Education, Purdue University, Lafayette, Ind., or *Automation,* Penton Bldg., Cleveland 13, Ohio.

# Meetings and Shows

**April 9-13—**
**American Society of Mechanical Engineers.** Oil and Gas Power Conference and Exhibit to be held at the Jung Hotel, New Orleans. Additional information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

**April 10-11—**
**Society of Naval Architects and Marine Engineers.** Annual Spring Meeting to be held at the Hotel Mark Hopkins, San Francisco. Further information can be obtained from society headquarters, 74 Trinity Place, New York 6, N. Y.

**April 10-14—**
**International Institute of Welding.** Annual Assembly, to be held at the Sheraton-Atlantic Hotel, New York, will join the American Welding Society meeting the following week. Additional information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

**April 11-13 —**
**American Society of Lubrication Engineers.** Annual Meeting to be held at the Bellevue-Stratford Hotel, Philadelphia. Further information can be obtained from ASLE headquarters, 5 N. Wabash Ave., Chicago 2, Ill.

**April 17-19—**
**Fifth Conference on Manufacturing Automation,** cosponsored by Purdue University and Manufacturing Engineering Council and *Automation* magazine, to be held at Purdue University, Lafayette, Ind. Further information is available from K. E. Glancy, Div. of Adult Education, Purdue University, or *Automation,* Penton Bldg., Cleveland 13, Ohio.

**April 17-21—**
**American Welding Society.** 42nd Annual Convention and Welding Exposition to be held at the Coliseum, New York. Technical meetings will be held at the Commodore Hotel. Additional information is available from AWS, 33 W. 39th St., New York 18, N. Y.

**April 17-21—**
**Business Equipment Exposition** to be held in the Coliseum, New York. Sponsor is the Office Equipment Manufacturers Institute. Further information is available from OEMI, 777 14th St. N.W., Washington 5, D. C.

**April 18-20—**
**New England Electrical Trade Show** to be held in the Commonwealth Armory, Boston. Sponsor is the Electrical Manufacturers Representatives Club of New England. Additional information can be obtained from Charles A. Stone, 45 Morrissey Blvd., Boston 25, Mass.

**April 20-21—**
**Society of the Plastics Industry Inc.** Annual Western Section Conference to be held at the Hotel del Coronado, Coronado, Calif. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

**April 23-26—**
**American Society of Mechanical**

first in silicones

Dow Corning

# SILICONE NEWS

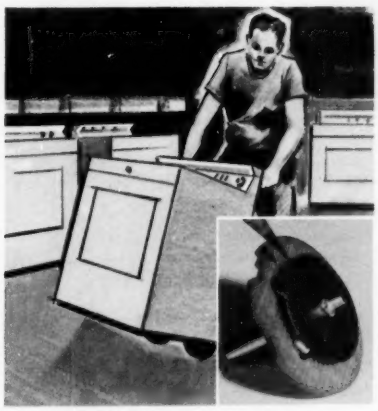
for design and development engineers • No. 81

## Lubricate at -100 or 450F

**The more critical the operating requirements for a design, the better the reason for specifying a silicone lubricant. Here are a few examples of the kind of trouble-free performance you can expect with silicone oils and greases.**

**Heat . . .** New magnetic clutch for electric motors can slip continuously, and therefore must dissipate heat . . . heat that is conducted to the ball bearings. A silicone grease was specified for these bearings because it doesn't thin out when temperatures skyrocket. The magnetic clutch is manufactured by Vickers Inc., Electric Products Division, Sperry Rand Corporation, St. Louis, Mo.

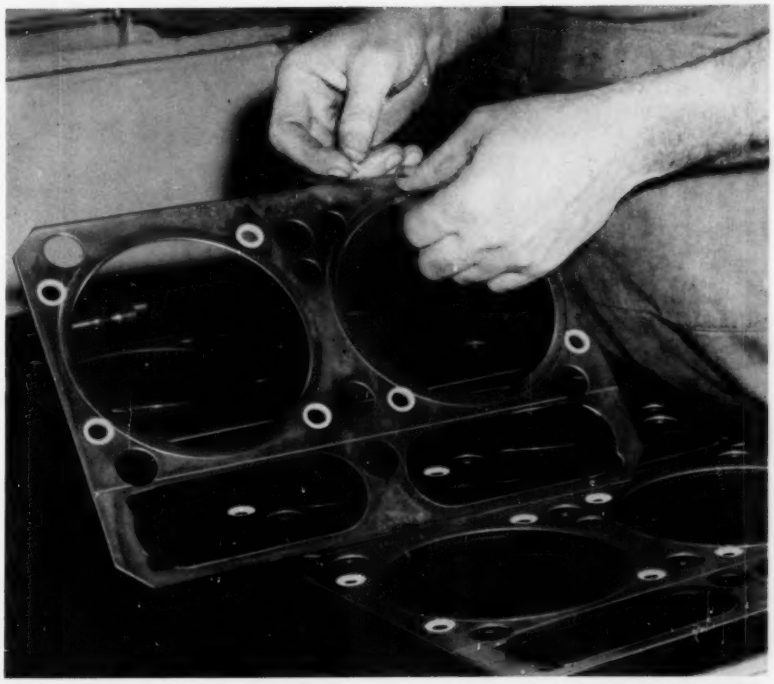
**Cold . . .** Silicone lubricants don't stiffen with cold. Even at 100 degrees below zero, they keep things rolling. For plastic and metal bearings in refrigerators . . . for conveyor bearings in commercial freezers and cold storage areas . . . silicones virtually assure lifetime lubrication.



**Long Shelf Life . . .** Lubricated with silicones, timing devices for automatic dryers operate accurately and quietly after extended storage. Timers are made by Appliance Manufacturing Company of Van Buren, Indiana. Silicones also provide an economical way to lubricate moving plastic parts on appliances and toys.

If your special design encounters extreme heat, cold, extended storage, weathering —a Dow Corning silicone oil or grease may well end your lubricating problems on metal, plastic or rubber parts.

For a free copy of an 8-page brochure, "Silicone Lubricants Give Longlife Service", circle . . . . . *No. 241*

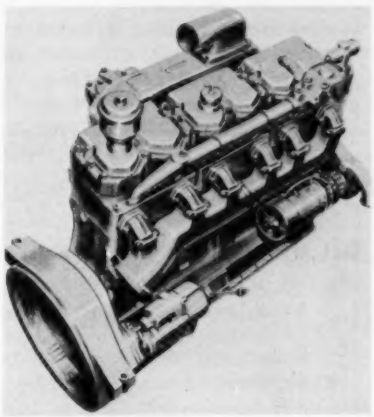


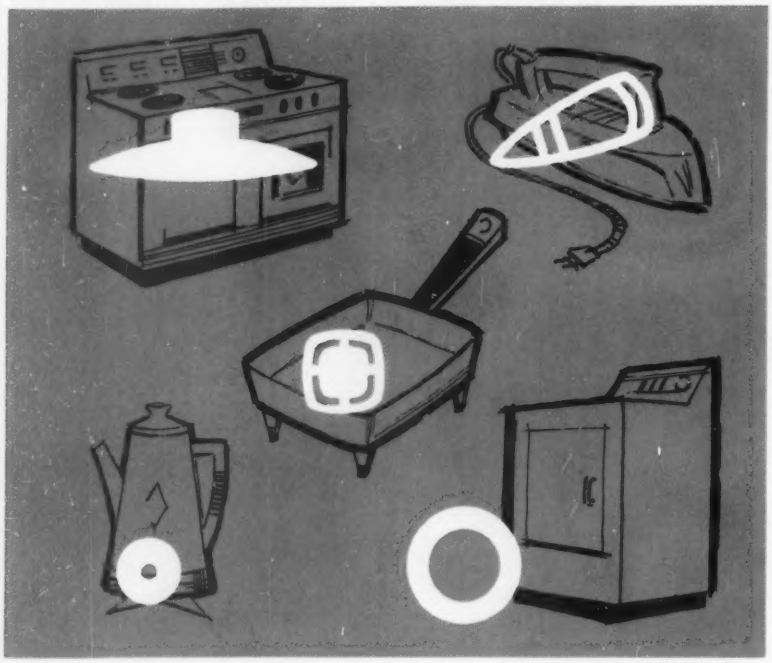
## 100,000 MILE GUARANTEE!

**To keep today's high powered construction equipment and on-highway trucks operating efficiently requires engines that are really rugged! And ruggedness is what Cummins Engine Company, Columbus, Indiana has built into their line of diesel engines. *These engines are guaranteed for 100,000 miles or 3,600 hours!***

Important to dependable performance of the engines are 24 cylinder-head grommets made of SILASTIC®, the Dow Corning silicone rubber. Positioned over the entrances to coolant passages in the top of the block, these silicone rubber rings prevent leakage of coolant and antifreeze into the engine and the costly damage that could result. The grommets snap into the cylinder head gasket where they remain flexible and sure-sealing, despite attack by cooling fluids and engine temperatures in the 300 to 350 F range.

Because it is doing so many difficult jobs well, designers no longer challenge Silastic's immunity to deterioration by 500 F heat, —130 F cold, weathering, ozone, corona, and oxidation aging. Today's designers concentrate on making the most efficient use of the properties of Silastic to increase end-user satisfaction with products like frypans, automotive transmissions, range doors, tire valves . . . even baby bottle nipples. Thanks to Silastic, the rubber that never grows old . . . never gets tired . . . many of tomorrow's products will last longer, perform more efficiently, cost less to maintain. Will yours? *(Cont. Pg. 2)*





# NEW RUBBERY ADHESIVE

**Here's a really new answer to many difficult sealing problems. It's a new form of SILASTIC® RTV, the silicone rubber that cures at room temperature.**

Big advantage of this new ready-to-use adhesive is that it sticks to almost any surface including metals and plastics. You can use it anywhere . . . there's no loss of adhesion or flexibility when exposed to extreme temperatures or high moisture and humidity conditions. Another plus: long term aging or storage doesn't crack or check Silastic RTV.

**Fast, versatile.** No need to add catalyst when using this new adhesive. Just squeeze from tube . . . it flows smoothly right where you want it. There's no slumping or sagging during or after application *even on vertical surfaces.* After a few hours exposure to air, the adhesive cures to form a firm and flexible silicone rubber that stays in place even when exposed to low pressure steam or temperatures ranging from —100 to 500 F.

For complete information about this new rubbery adhesive, contact our nearest office or circle . . . . . *No. 242*

## SILASTIC *(Cont.)*

Over 100 rubber companies manufacture these standard parts from Silastic:

- Seals and Gaskets
- O-Rings
- Mechanical Rubber Goods
- Coated Fabrics
- Ducting and Hose
- Extrusions
- Sleeving
- Electrical Tapes
- Sponge
- Wire and Cable

For list of these suppliers and more information about Silastic, circle . . . *No. 243*

## new literature and technical data on silicones

**New Molding Compound** for 700 F electrical uses features long term stability, excellent resistance to thermal shock, low dissipation factor and good arc resistance. The history and properties of this mineral-filled silicone molding compound, which was developed especially to meet stringent performance requirements, are presented in an article from a recent issue of MATERIALS IN DESIGN ENGINEERING. To obtain a copy, circle . . . . . *No. 244*

**Compiled for Advance Research** and development engineers, an eight page reference provides a convenient guide to selecting the most suitable silicone fluid medium when designing damping, springing, coupling and related mechanical devices. Includes tables, graphs and detailed information about properties that enable Dow Corning silicone fluids to increase efficiency of existing designs and make possible new design changes. *No. 245*

**Four Simple Steps** to making silicone rubber molds for short run castings are described in an article reprinted from PRODUCT ENGINEERING. Silastic RTV, the fluid silicone rubber that cures at room temperature, makes it possible to produce flexible molds and patterns for casting metal or plastic parts, even with most intricate detail, cheaply and quickly. An ideal means of making prototype parts. *No. 246*

**Silicones in Appliances** can give that extra edge for extra sales. This colorful booklet tells where and how silicones are being designed into appliances to give more efficient and reliable performance. It shows how planning around silicones can make good products better. *No. 247*


**You And The Silicones** — a new 30-minute, full color movie lets you see silicones in action. It's an all-encompassing, dramatic documentation of designers' adaptations of these versatile engineering materials in different applications. For information about arranging for a free showing, request . . . . . *No. 248*

Dow Corning Corporation, Dept. 4915, Midland, Michigan
Please send me: 241 242 243 244 245 246 247 248

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TITLE _____
COMPANY _____
STREET _____
CITY _____ ZONE ____ STATE _____

**SILICONE NEWS** is published for design and development engineers by

first in silicones

**Dow Corning CORPORATION**
MIDLAND, MICHIGAN

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FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE IN COUPON ABOVE, OR REFERENCE NUMBER ON READER SERVICE CARD

**Engineers.** Metals Engineering Conference to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

**April 24-26—**

**Association of Iron and Steel Engineers.** Spring Conference to be held at the Jefferson Hotel, St. Louis. Further information is available from AISE, 1010 Empire Bldg., Pittsburgh 22, Pa.

**April 26-27—**

**High-Temperature Materials Conference** to be held at the Pick-Carter Hotel, Cleveland. Sponsor is the Cleveland section of the American Institute of Mining, Metallurgical, and Petroleum Engineers, in co-operation with the High Temperature Alloys Committee and the Refractory Metals Committee of the Institute of Metals Div. of the Metallurgical Society. Further information is available from the Metallurgical Society of AIME, 29 West 39th St., New York 18, N. Y.

**April 26-28—**

**Institute of Radio Engineers.** 1961 Conference of the Seventh Region to be held at the Hotel Westward Ho, Phoenix, Ariz. Further information can be obtained from Everett Eberhard, Motorola Military Electronics Div., 8201 E. McDowell Rd., Scottsdale, Ariz.

**May 2-3—**

**Lead Industries Association.** Annual Meeting to be held at the Drake Hotel, Chicago. Additional information can be obtained from association headquarters, 292 Madison Ave., New York 17, N. Y.

**May 3-6—**

**American Helicopter Society.** Annual National Forum to be held at the Sheraton-Park Hotel, Washington, D. C. Further information can be obtained from society headquarters, 2 E. 64th St., New York 21, N. Y.

**May 8-12—**

**American Foundrymen's Society.** Castings Congress and Exposition to be held at Brooks Hall and the Civic Auditorium, San Francisco. Further information can be obtained from AFS headquarters, Golf and Wolf Roads, De Plaines, Ill.

**May 9-11—**

**Western Joint Computer Conference** to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from conference headquarters, 721 N. La Brea Ave., Los Angeles 38, Calif.


**May 10-12—**

**American Society of Mechanical Engineers.** Production Engineering Conference to be held at Cobo Hall, Detroit. Additional information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

**May 10-12—**

**Society for Experimental Stress Analysis.** Spring Meeting to be held at the Benjamin Franklin Hotel, Philadelphia. Further information can be obtained from SESA headquarters, 21 Bridge Square, Westport, Conn.

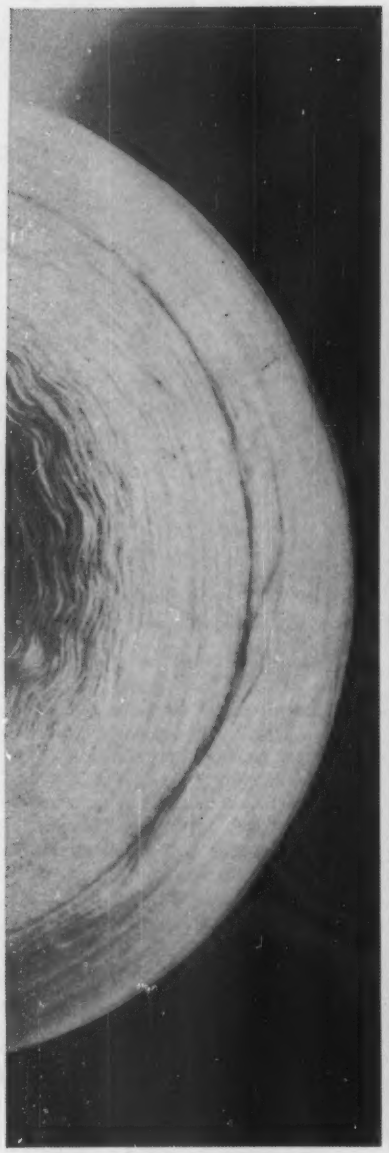
**May 14-17—**

**National Fluid Power Association.** Spring Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from association headquarters, 1618 Orrington Ave., Evanston, Ill.

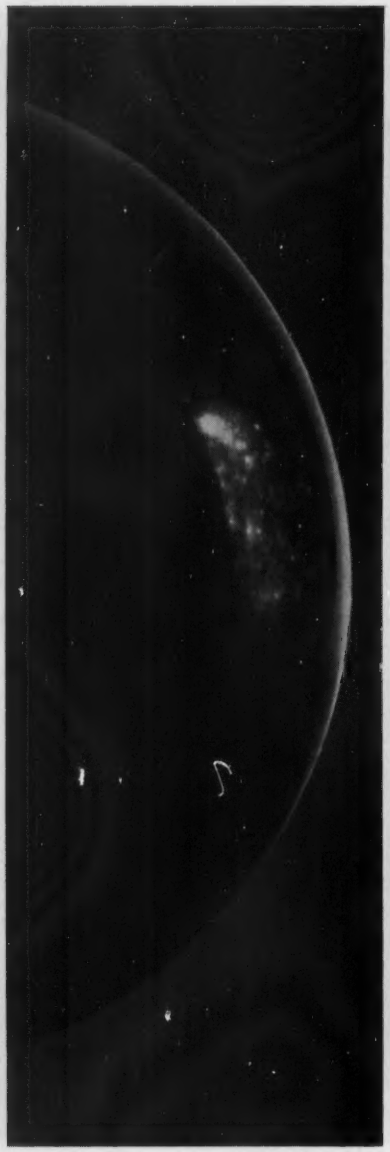
**May 15-16—**

**American Institute of Electrical Engineers.** Packaging Industry Technical Conference to be held at the New Ocean House, Swamp-

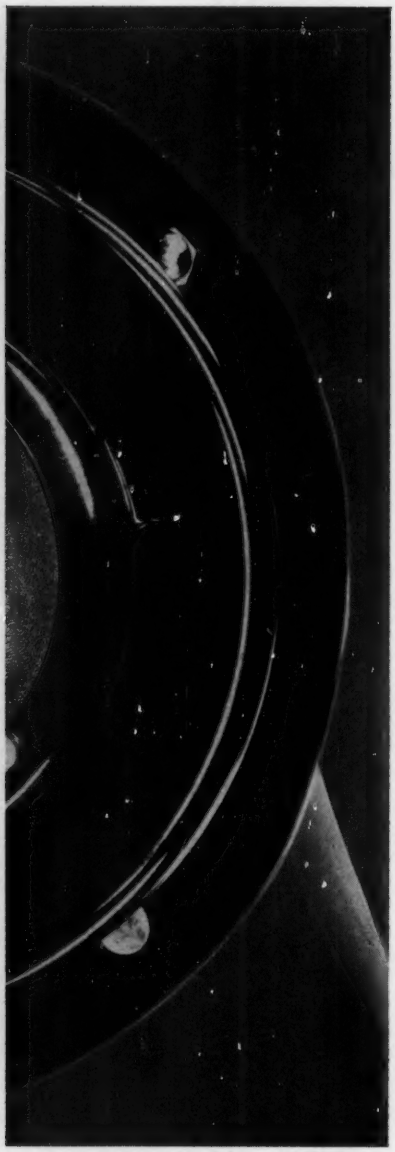
(*Please turn to Page 42*)



In today's booming textile industry, special Veeder-Root counters record pick and hank production shift after shift, and automatically control cut lengths of fabric woven.



Rugged, long lasting Veeder-Root electrical and mechanical counters accurately tally and control frames and games for bowling alley operators everywhere . . . help keep profits rolling.

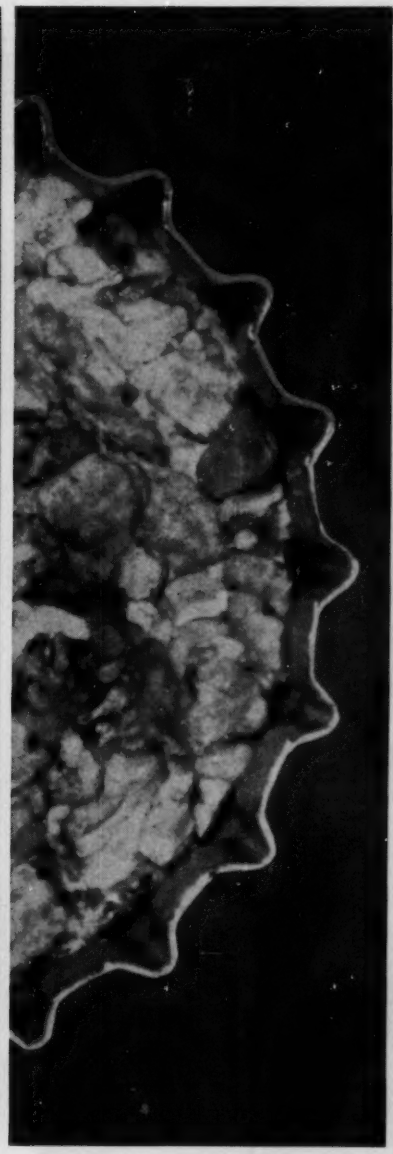


Counting memos, reports, letters, addresses—Veeder-Root counters pay off on a wide variety of office machines, providing businessmen with that extra measure of control.

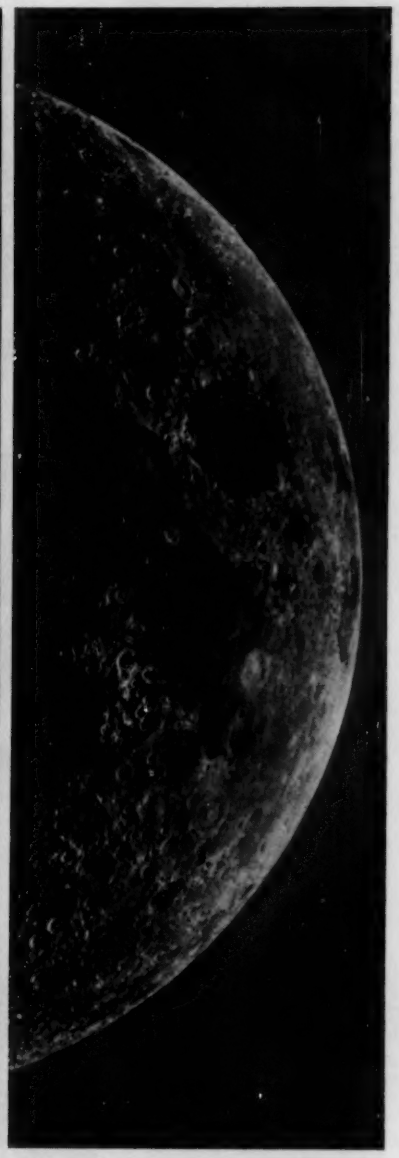
**Indicate, Coordinate, Automate with Veeder-Root Counters!**
You'll find that they provide a simple, surprisingly economical way to record facts...or inter-relate them... or activate other machinery in your plant. See how these

counting controls for industry, defense and space exploration

In farm mechanization and heavy construction, equipment designers use Veeder-Root counters to report productive work accomplished by harvesting machines and giant earth movers.



Whether it's counting bottle caps, pills or tiles, Veeder-Root electronic counters with photo-electric input record production up to a surprising 300,000 units per minute.



Minute, ultra-sensitive measuring instruments designed by Veeder-Root go into frequency indicators, altimeters, radar systems—even guide our missiles to outer space!

**versatile counters are adding value to newly designed and existing equipment. Talk with your Veeder-Root representative or write: Veeder-Root Inc., 70 Sargeant St., Hartford 2, Connecticut. count on ... Veeder-Root**

(*Continued from Page 39*)

scott, Mass. Additional information is available from AIEE, 33 W. 39th St., New York 18, N. Y.

May 21-23—

**Fluid Controls Institute Inc.** Annual Meeting to be held at the Cloister, Sea Island, Ga. Further information is available from FCI headquarters, P. O. Box 667, Pompano Beach, Fla.

May 22-25—

**Design Engineering Show and Conference** to be held at Cobo Hall, Detroit. Conference is sponsored by the Machine Design Div. of ASME. Further information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

## Short Courses and Symposia

April 11-12—

**Seminar on Engineering Standards: Procedures, Practices, and Problems** to be held at the University of Wisconsin. Further information is available from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

April 17-19—

**Seventh National Symposium on Instrumental Methods of Analysis,** to be held at the Shamrock Hilton Hotel, Houston. Sponsor is the Instrument Society of America; additional information is available from Meetings Services Dept., ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

April 17-21—

**Short Course on Strain Gage Techniques,** sponsored by the Society of Experimental Stress Analysis and Southwest Research Institute, to be held at the Granada Hotel, San Antonio, Texas. Emphasis will be placed on high and low-temperature applications, and lectures will be supplemented by laboratory work. Additional information can be obtained from Dr. M. M. Lemcoe, Southwest Research Institute, P. O. Box 2296, San Antonio 6, Texas.



Circle 420 on Page 19

**April 18-19—**

**Engineering Institute on Nomography** to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

**April 18-19—**

**Process Planning Seminar** to be held at the Statler Hilton Hotel, Cleveland, under the sponsorship of American Society of Tool & Manufacturing Engineers. Further data is available from ASTME, 10700 Puritan Ave., Detroit 38, Mich.

**April 30-May 4—**

**Aero-Space Instrumentation Symposium,** sponsored by Instrument Society of America, to be held at the Adolphus Hotel, Dallas. Further information is available from W. J. Gabriel, Group Engineer, Convair Div., General Dynamics Corp., Ft. Worth, Texas.

**May 8-9—**

**Lubrication Symposium,** sponsored by American Society of Mechanical Engineers, to be held at the Deauville, Miami Beach, Fla. Additional information is available from ASME Meetings Dept., 29 West 39th St., New York 18, N. Y.

**May 8-10—**

**Fourth National Power Instrumentation Symposium,** sponsored by Instrument Society of America, to be held at the La Salle Hotel, Chicago. Additional information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

**May 9-10—**

**Engineering Institute on Product Development** to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

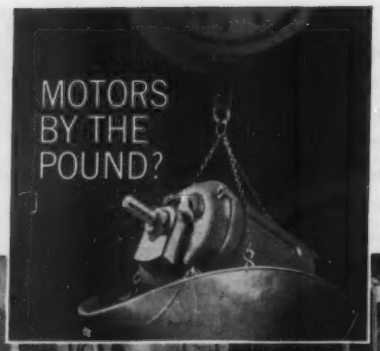
**May 23-24—**

**Engineering Institute on Direct Energy-Conversion Systems** to be held at the University of Wisconsin. Further information is available from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6. Wis.

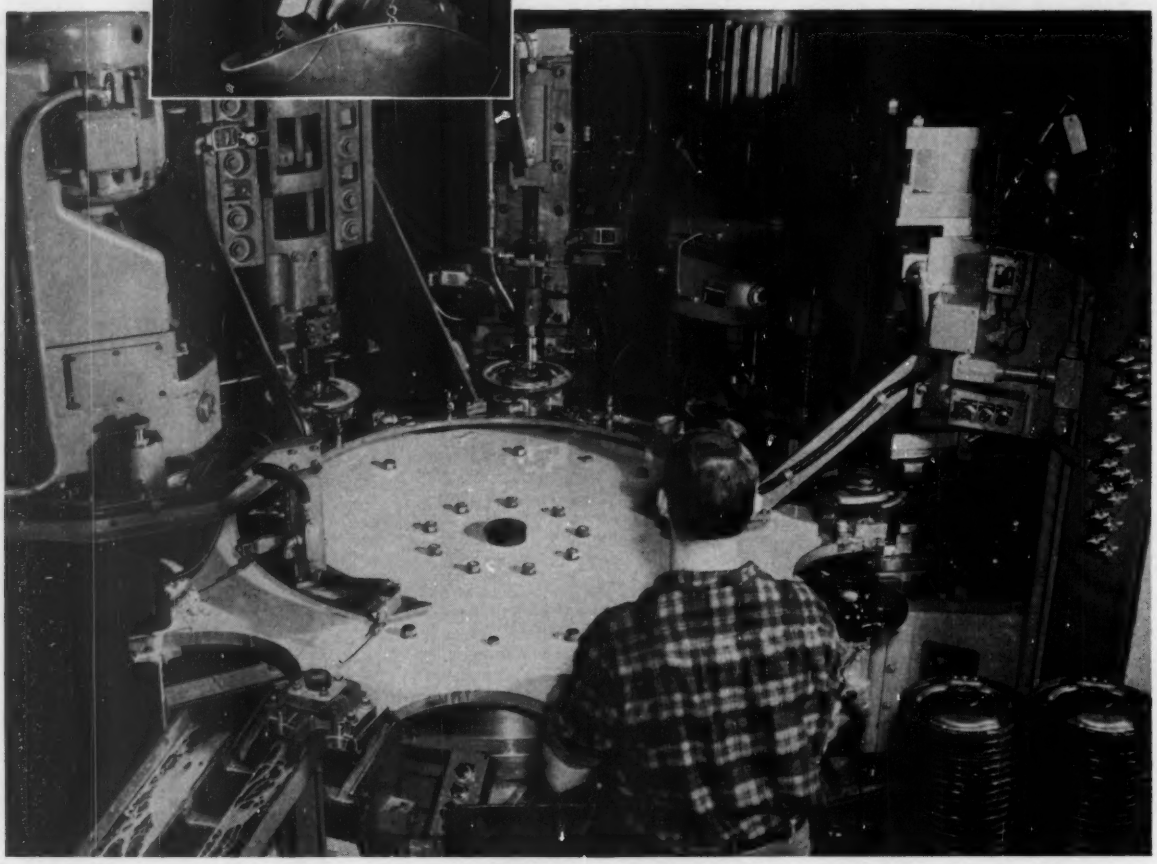




Circle 421 on Page 19




*You're buying motors by the pound when price is the only consideration*



# Today's machine tools can't afford motors selected on the basis of price alone

Modern machine tools are designed to manufacture products of great precision at the lowest possible cost. But a machine tool is only as productive as the electric motors that drive it. Motors purchased on the basis of price alone often fail to give their users the greatest value in terms of useful service life.

The selection of the right motor to power your products requires not only specification of type, rating and operating characteristics, but consideration of such factors as uniform, troublefree performance, dependable long-life operation, the reputation of the manufacturer, and his ability to provide immediate repair parts and service —when and where they're needed. Wagner® motors have earned their reputation for proven dependability in their specific applications.

Next time you buy motors, check beyond the purchase price. Make sure that you get all the performance you need—with motors that will do the job.

Wagner motors have been getting the job done for more than 65 years. Your Wagner Sales Engineer will be glad to show you why. Call him for an analysis of your next motor application, be it for plant or product.

*Branches and Distributors in all Principal Cities*

**Wagner Electric Corporation**

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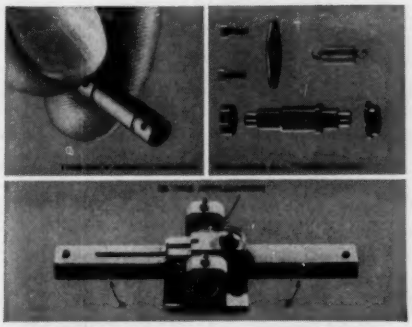
WM61-4


# NEW FROM BENDIX!
# THE FREE-FLEX PIVOT BEARING

## Positively no friction or backlash... requires no lubrication

It's the Bendix Flexural Pivot. Made of pairs of flat, crossed springs, the new Bendix® Free-Flex Pivot Bearing is completely free of friction and backlash—and eliminates the need for lubrication. This compact, integrated unit is easy to install, easy to use. And its performance is consistency itself.

Bendix Free-Flex Bearings come in two types. The Cantilever type for supporting overhung loads. The double-end-supported type for bridge-supporting a central load. Both are corrosion-resistant steel. Both have high lateral and radial rigidity plus low torsional rigidity.



Before Free-Flex, this air data sensor component had six parts, requiring machining tolerances of .0003". With Free-Flex Bearing, the closest tolerance required is only .005".

Our first low-cost standard models come in 3/16", 1/4", 3/8", and 1/2" diameters with three deflection limits: ±30°, ±15°, and ±7.5°. Fast delivery of any of our 30 standard combinations. A little longer if you require a special type. We'll be glad to send you details and prices on request. Write today.

Export Sales and Service: Bendix International, 205 E. 42nd Street, New York 17, New York
Canada: Aviation Electric, Ltd., 200 Laurentian Blvd., Montreal, Que.

Bendix Utica Division
Utica, New York

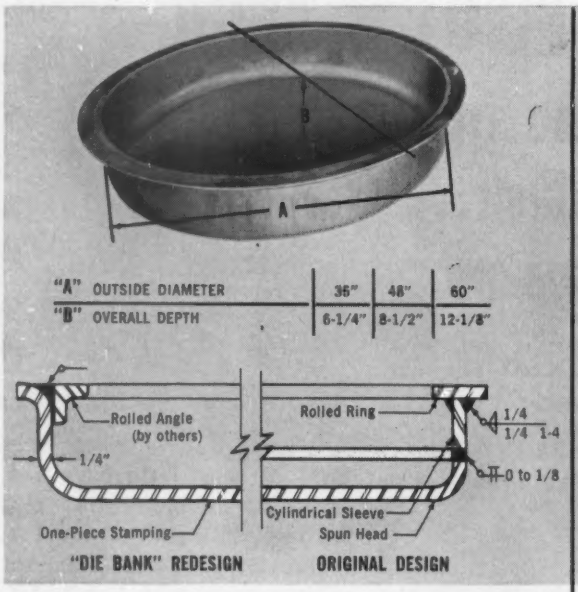
THE Bendix CORPORATION



Circle 423 on Page 19

# How to Improve Parts Design with This Fresh Approach to Stamping

**Many parts in use today are better as a result of design refinements suggested by COMMERCIAL's stamping experts. The examples below demonstrate how these design refinements have resulted in superior parts for the OEM at lowered cost. These examples may appear to you as unusual in design and this is the point...**

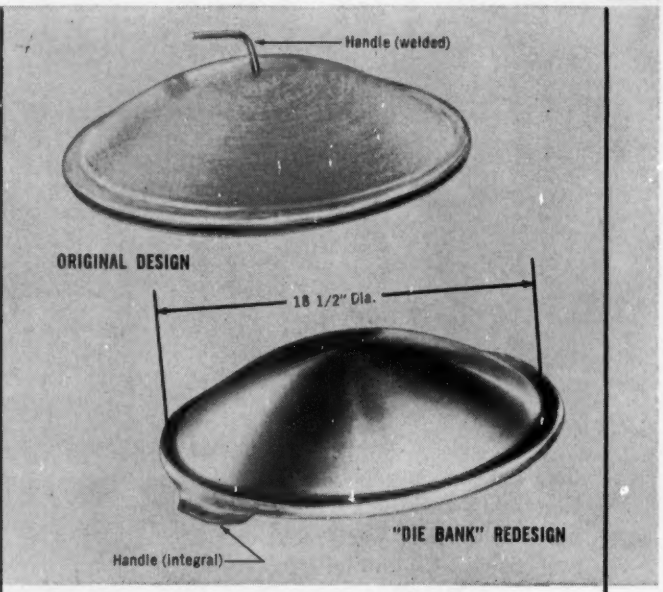



**One Piece Stamping . . . Improves Appearance, Replaces Three Piece Weldment**

Circular steel boiler doors 36", 48", 60" diameter were formerly fabricated from three basic components—spun head, cylindrical sleeve and ring rolled the hard way.

Problem: eliminate accumulative assembly variables caused by inherent non-uniformity of three components—upgrade product appearance.

Solution: one piece smooth surface COMMERCIAL steel stamping shaped in a die assembled from stock "die bank" components (for details of "die bank", see box upper right). Stamping tolerances plus or minus 1/16" (flat across flange within 1/16"). Result—accurate finished product because former difficult assembly and time-consuming fitting-up problems eliminated. All outside exposed welds (about 16 ft. on the 48 in. side) and grinding discontinued. An end product with improved appearance—better product appeal.

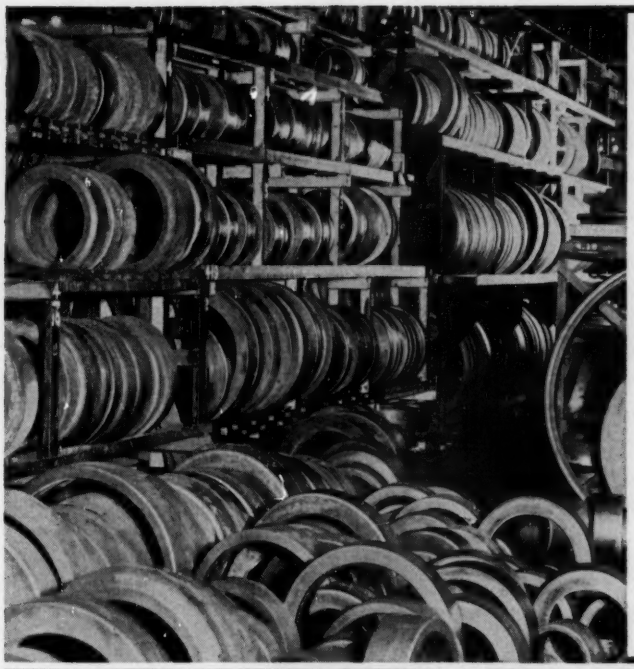



**Stampings . . . Unitize Construction, Replace Inaccurate Stainless Steel Spinnings**

Original contruction of bulk milk cooler used tank manhole cover spinning—requiring welding, grinding and polishing.

Problem: reduce production finishing time, overcome welding heat distortion of stressed metal-spinnings, increase strength, produce uniform parts and improve sanitation properties.

Solution: COMMERCIAL's "die bank" proved a nucleus for a one-piece stamping redesign including integral handles. Basic stamping details—size, shape and gauge were tailored to stock die components. Realization—smoother finish of stamping creates a more sanitary, better appearing tank. Closer tolerances of stamped cover provide flange with definite "drop-on" vacuum seal. Fewer parts resulting from stamping. Unitization greatly diminishes production time and component cost.



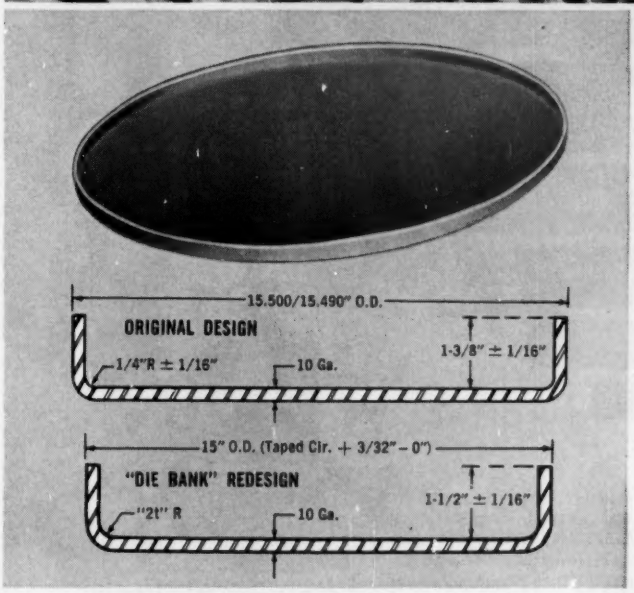
## "Die Bank" Facts

Over 50,000 stock die components stand ready to go to work for you at COMMERCIAL. These components can be combined in endless variety—can prove, as they have for others, invaluable in your stamping design.

Components for circular stampings cover a diameter range from 2½" to 72". To 30" O.D., increments are in units of 1". Over 30" O.D., increments progress from 1" up to 6" for the largest diameter. Under 24" O.D., many sizes are available in fractional inches.

Stampings from these die components range from 20 gauge to ¾" thick. Contour can be flat or dished to any one of many patterns. Stampings can be supplied with vertical, horizontal or reverse flanges—or without any flange.

Use of COMMERCIAL's "die bank" results in many stampings made to basic original design free of heavy tooling cost—minor design latitude often eliminates all die expense. Catalog 200-C1 "Standard Metal Shapes" should be in your hands when preliminary designs go on the board.




**"Die Bank" Stamping Gets O. K. . . .**
**Reduces Cost of Tailored Design**

Original design of agriculture combine cylinder head called for odd fractional dimensions. Tolerances were tighter than necessary and applied in conflict with best stamping practice. Details were established without knowledge of COMMERCIAL's "die bank". Result—high unit cost to produce basic part to individually tailored size. Special dies, not in existence, were required.

Problem: redesign a more practical part to be mass produced at low unit-cost—eliminate special die cost.

Solution: simple redesign using stock die components from COMMERCIAL's "die bank" cancelled out $1850 partial die cost required for tooling original design. Net die cost: zero. Piece price reduced: 16 cents. Savings on initial requirement: over $2200. A stamping made to commonly accepted tolerances at lower cost without sacrificing product quality was the answer.

## Advantages of Stampings

*Economy of production*
*—metal conservation, waste material minimized, stamped parts have greater surface area than blank the part is made from—without loss in strength*
*—high quantity man-hour output from fast production machines—low unit cost*

*Greater strength: predicted, controlled, unvarying*
*—higher proportionately, in relation to weight, than possible in other metalworking processes*

*Enhanced appearance: finish is predictable, uniform, "as specified"*
*—multiple selection of basic material and its finish facilitates maintaining appearance in stamping the part or its further processing*

## Features of COMMERCIAL Stampings

*Specialized equipment*
*—modern presses with capacity over 2000 tons; facilities located in three strategic metal producing centers*

*Economical large or small runs*
*—medium to heavy, shallow or deep drawn stampings*

*Facilities for finishing*
*—drilling, boring, tapping, machine trimming, burning, welding, painting, etc.*

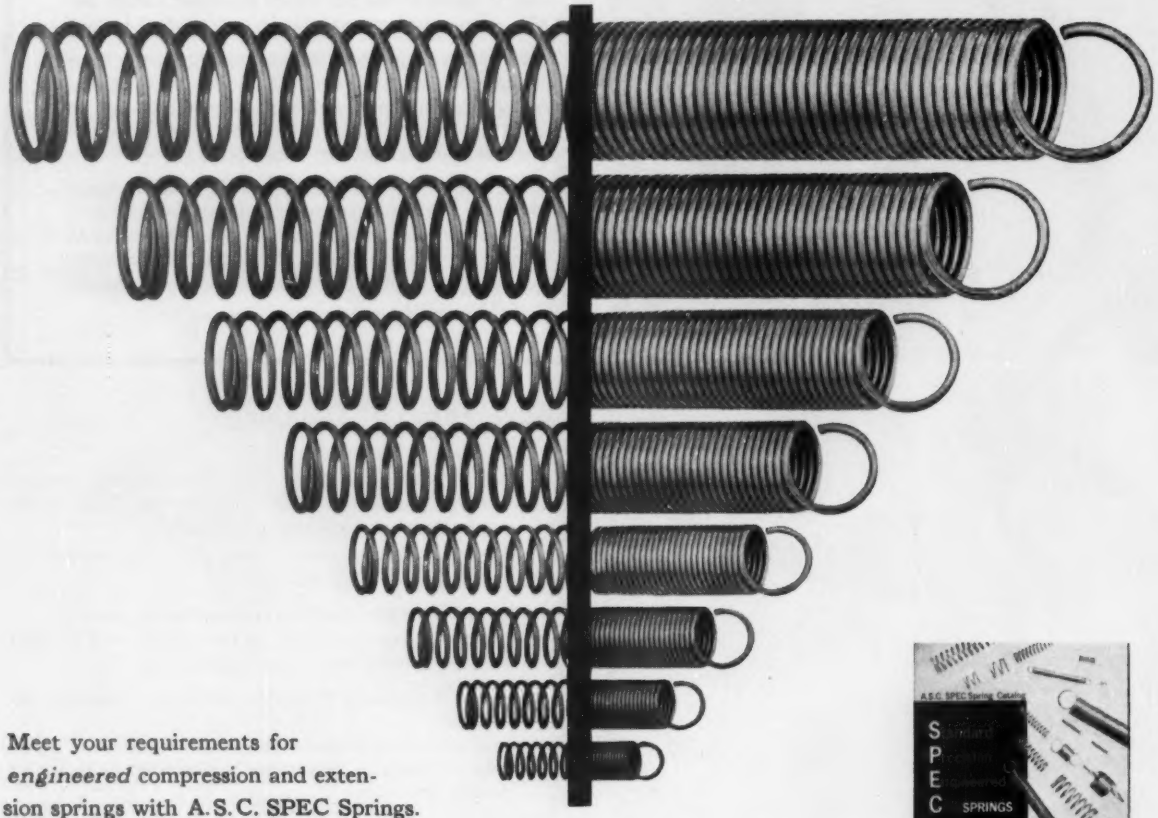
While designs are on the board, or redesign of parts in usage are fresh in mind, why not call on COMMERCIAL'S technical service—send print, sketch, sample or prototype. Address: Commercial Shearing & Stamping Company, Dept. S-13, Youngstown 1, Ohio.

**COMMERCIAL**
**shearing & stamping**

# IN STOCK–for Fast Delivery–Hundreds of Sizes

# A.S.C. SPEC Springs

## Standard Precision Engineered Coil Springs



Meet your requirements for *engineered* compression and extension springs with A.S.C. SPEC Springs.

- Pinpoint your needs quickly.
- Especially convenient where quantities are moderate.
- No fuss or paperwork.
- No blueprints, drawings or samples needed.
- Match your requirements against the catalog list.
- Order by catalog number.
- Over 1,500 standard sizes in stock.

A.S.C. SPEC Springs are made from wire certified to military and aircraft specifications, in various lengths, diameters, rates, and loads up to 30 lb. They meet industry and military standards. Material is either music wire or stainless steel. All except smallest compression springs are squared and ground. Extension springs have regular loops. Other end treatment and loops optional.




*Whether your need is immediate or future, write now for the A.S.C. SPEC Spring catalog and price list. Keep it handy as a time-saving, useful spring service.*

6107

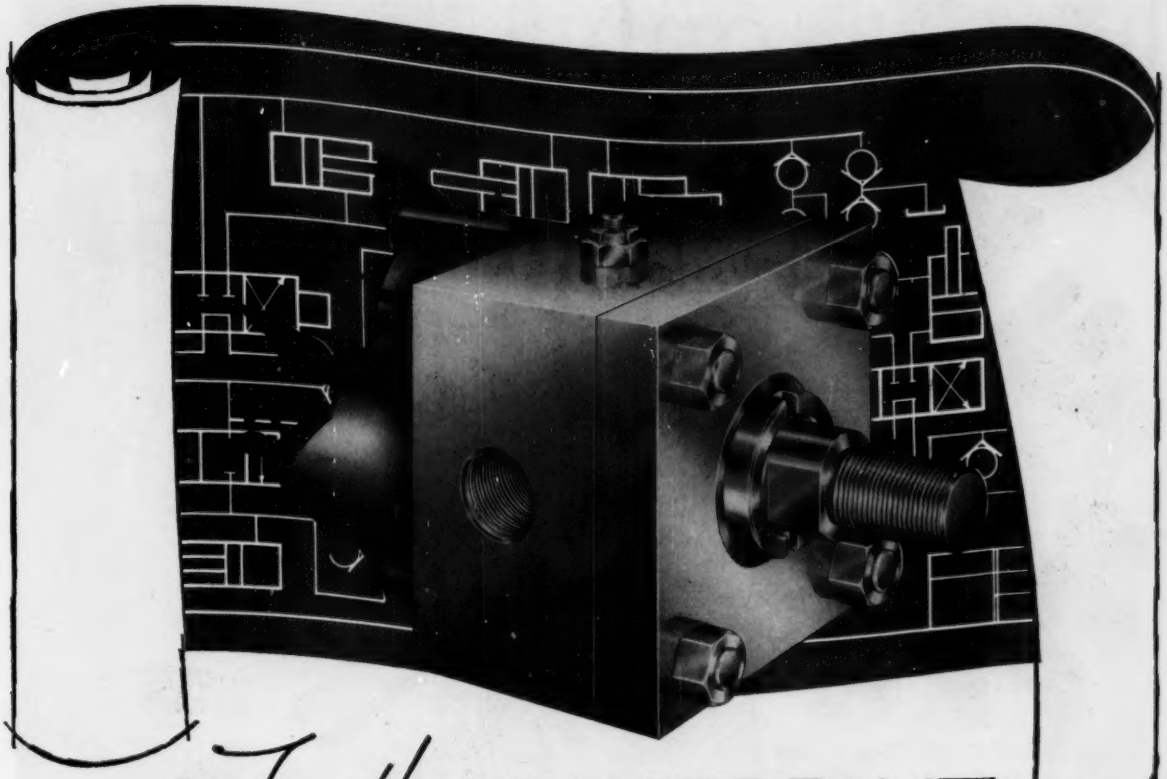
## Associated Spring Corporation

**General Offices: Bristol, Connecticut**

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
F. N. Manross and Sons Division, Bristol, Conn.
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
Cleveland Sales Office, Cleveland, Ohio
Chicago Sales Office, Chicago, Ill.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Mattoon, Ill.
Milwaukee Division, Milwaukee, Wis.
Seaboard Pacific Division, Gardena, Calif.
Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que.



*Circle 425 on Page 19*

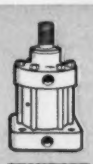


# *For the BLUEPRINT of your products...*

**SPECIFY T-J CYLINDERS . . . FOR YOUR POWER DRIVE DESIGN • APPLICATION OR REPLACEMENT MAINTENANCE**

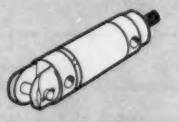
From its blueprint stage to its maintenance engineering requirement sheet, your product will assure MORE power drive precision and service, if T-J cylinders are specified. T-J's complete line too, from the Spacemaker to the new replaceable Squair Head, can be the answer to any power problem. Write or call The Tomkins-Johnson Company, 2425 W. Michigan Ave., Jackson, Michigan, today!

**T-J OFFERS THE ONLY COMPLETE CYLINDER LINE**

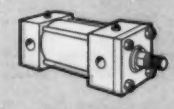


STANDARD HYDRAULIC

STANDARD PNEUMATIC



AIR and HYDRAULIC SPACEMAKER



AIR and HYDRAULIC SQUAIR HEAD

HIGH PRESSURE SPACEMAKER

*PLUS complete catalog service*

T-J **TOMKINS-JOHNSON**

RIVITORS...AIR AND HYDRAULIC CYLINDERS...CUTTERS...CLINCHORS

Representation in all major areas, including Canada.



Circle 426 on Page 19

# this is the only tool needed


**to install a clutch-pulley unit that puts automatic control, smooth acceleration, instant start-stop —on any machine**



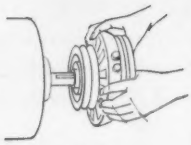

## New Warner Electro-Sheave

makes it possible to provide automatic pushbutton control on *specialized* machines — in a manner never before possible! The only tool you'll need to install this new Warner clutch-pulley package is an Allen wrench. No costly engineering or machining necessary. The addition of simple wiring to a control panel gives you *customized* machine control.

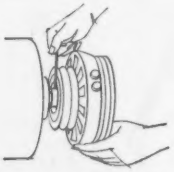
Now you can have the advantage of pushbutton engagement and disengagement of the drive at the motor — and with the addition of a secondary shaft brake, you can also have instant start-stop control. Warner now makes it possible for you to literally design "custom" control for special machines — in a fraction of the time — at a fraction of the cost.

*In just ten minutes* a Warner engineer can show you how simple it is to include an Electro-Sheave "control package" on any machine. He'll show you how it can increase production, reduce wear on motors, belts, starters. Call him today — or mail coupon below.

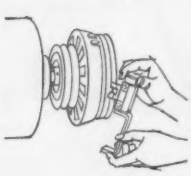
**Electro-Sheave MOUNTS IN 10 MINUTES!**



**1** Entire assembly slips over any standard NEMA motor shaft. No machining necessary.



**2** With clutch-sheave package in place, set-screws secure built-in shaft extension.



**3** Mount brushholder to motor frame, wire to control panel. Warner's Electro-Sheave is ready!

**WARNER ELECTRIC**

**Warner Electric Brake & Clutch Co. Dept. MF-3, Beloit, Wisconsin**

I'm interested in the advantages of Warner Electro-Sheaves. Rush me literature today!

Name_____

Title_____

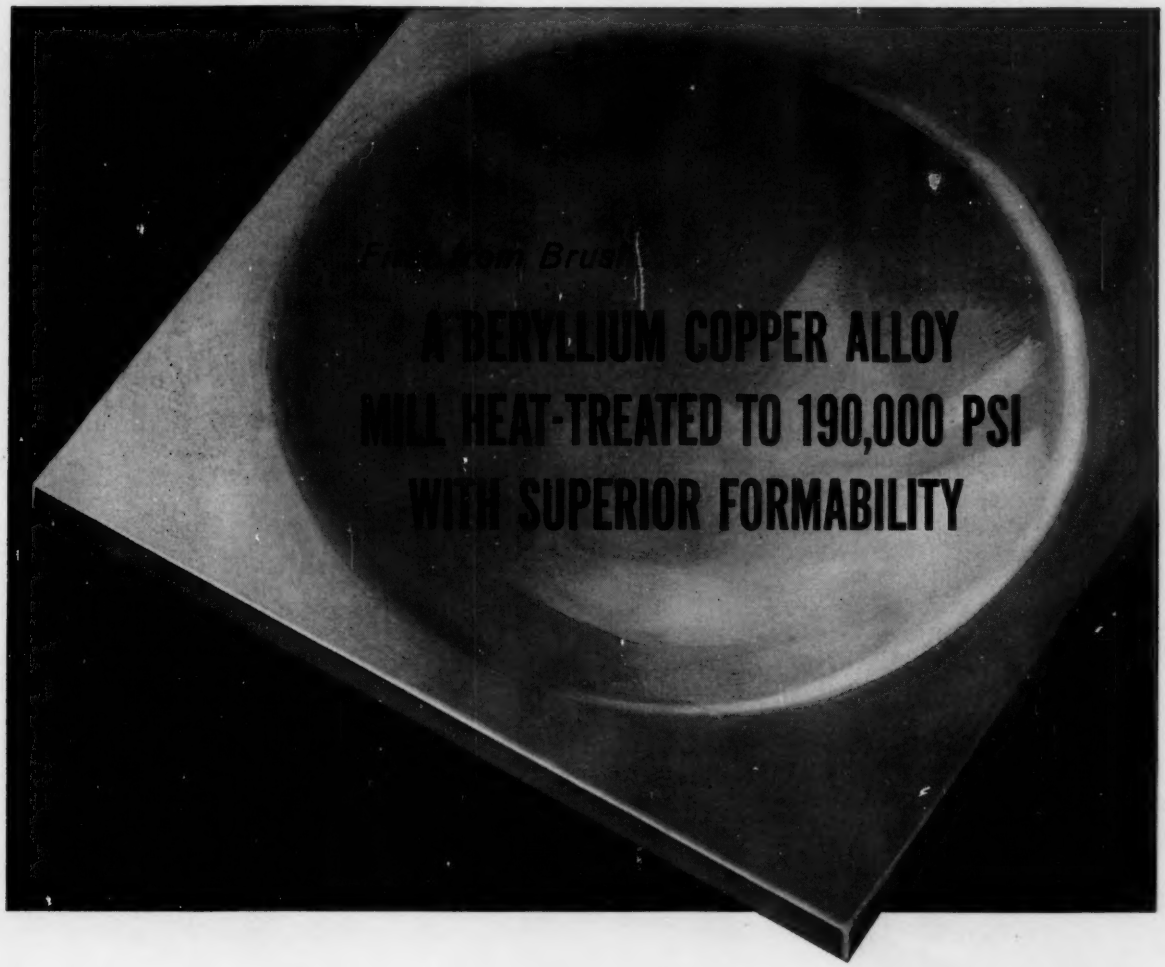
Company_____

Address_____

City_____ Zone_____ State_____



Circle 427 on Page 19

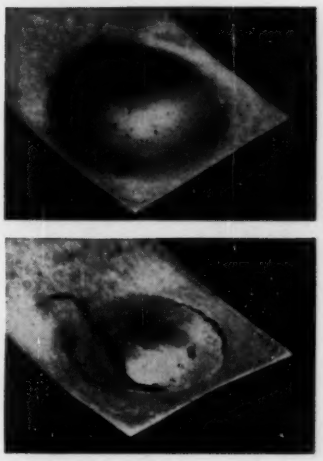



## New Brush 190 eliminates need for customer heat-treating

Formable to a greater degree than ever before possible with a high strength mill heat-treated beryllium copper strip, Brush 190 Alloy marks a significant technological advance.

With a tensile strength of 190,000 psi, it eliminates the need for customer heat-treating. And, as with all beryllium copper alloys, it has good electrical and thermal conductivity.

Brush 190 Alloy meets both ASTM Specification B 194 and Federal Specification QQ-C-533. Write today for technical data sheet. For additional information, call your local Brush representative or contact The Brush Beryllium Company, 5209 Euclid Avenue, Cleveland 3, Ohio, Phone ENdicott 1-5400, TWX CV 506.



Top photo: new Brush 190 strip successfully formed in the mill heat-treated condition.

Lower photo: Although mill heat-treated and having a lower tensile strength of 160,000 psi, 165 Alloy—recommended for parts where added strength and formability of Brush 190 is not required—could not take the identical forming operation.

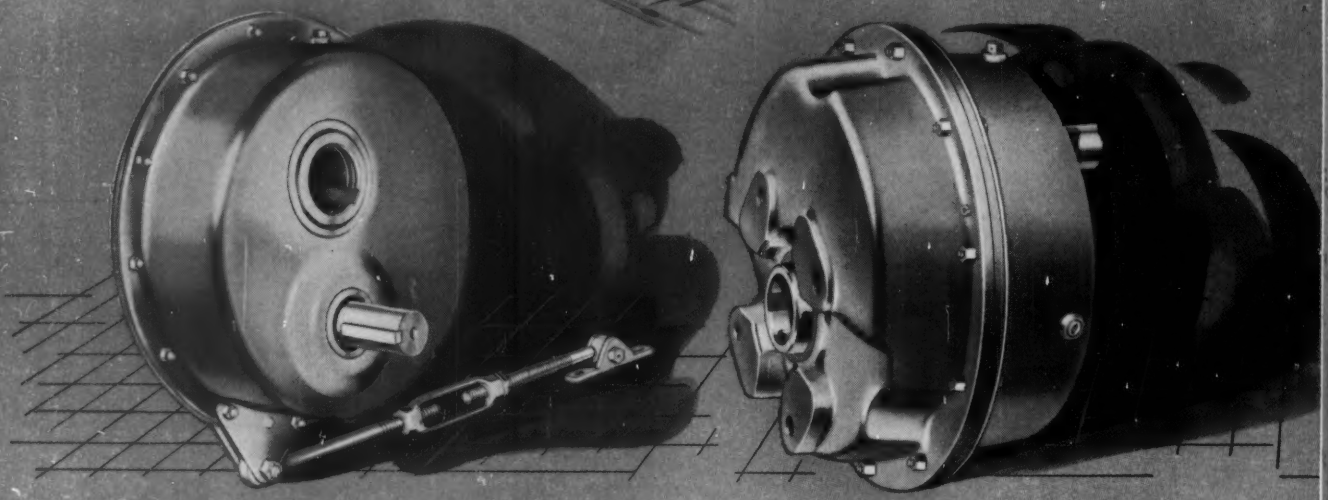
**THE BRUSH BERYLLIUM COMPANY**



Circle 428 on Page 19

# FALK

A GOOD NAME IN INDUSTRY



*Ask for Bulletin 7100*

*Ask for Bulletin 7100*

## 147 COMBINATIONS . . . horizontal or vertical applications . . . . . .

| UNIT SIZE | SHAFT MOUNTED DRIVES | | | | | |
|---|---|---|---|---|---|---|
| | RATIOS | | | MOTOR MOUNT | OVERLOAD RELEASE | BACK-STOP |
| | 4 | 14 | 24* | | | |
| 107J | X | X | X | X | X | X |
| 115J | X | X | X | X | X | X |
| 203J | X | X | X | X | X | X |
| 207J | X | X | X | X | X | X |
| 215J | X | X | X | X | X | X |
| 307J | X | X | X | X | X | X |
| 315J | X | X | X | X | X | X |
| 407J | | X | X | X | X | X |
| 415J | | X | X | X | X | X |
| 507J | | X | X | X | X | X |

| UNIT SIZE | FLANGE MOUNTED DRIVES | | | | | |
|---|---|---|---|---|---|---|
| | RATIOS | | | | BACK-STOP | MOTOR MOUNT |
| | 4 | 9 | 14 | 24* | | |
| 107J | X | X | X | X | X | X |
| 115J | X | X | X | X | X | X |
| 203J | X | X | X | X | X | X |
| 207J | X | X | X | X | X | X |
| 215J | X | X | X | X | X | X |
| 307J | X | X | X | X | X | X |
| 315J | X | | X | X | X | X |
| 407J | | | X | X | X | X |
| 415J | | | X | X | X | X |
| 507J | | | X | X | X | X |

½ to 125 hp. Up to 100,000 lb-in. torque

*20:1 ratio for sizes 107 and 115

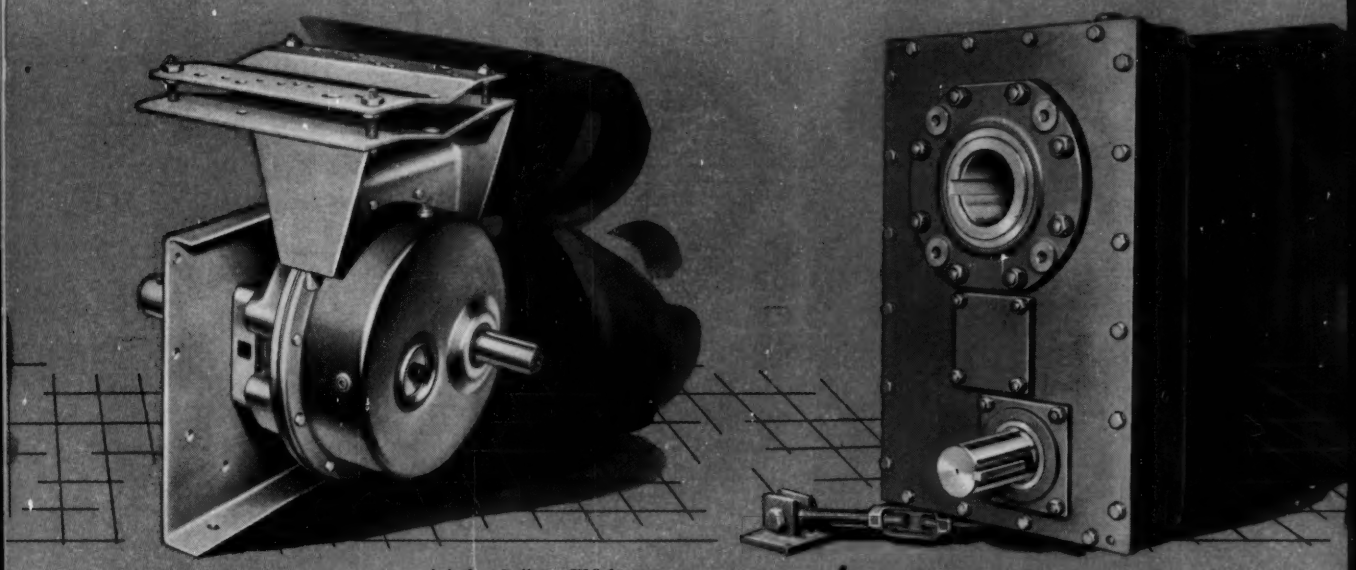
½ to 125 hp. Up to 100,000 lb-in.

*Exclusively* **FALK**... *Adaptability of all these three types of Falk Drives for use with Equi-Poised Motor Mount.* **This feature reduces costs of engineering and constructing motor bases and foundations.**

*Exclusively* **FALK**... ***Interchangeable rotating elements size-for-size between Shaft and Flange Mounted Drives or Screw Conveyor Drives. This feature simplifies stocking and maintenance for large users.***

# . the most complete line of SHAFT MOUNTED, FLANGE MOUNTED and SCREW CONVEYOR drives . . .

***The line with the exclusive EQUI-POISED motor mount***



*Ask for Bulletin 7106*

## . . . . AVAILABLE FROM STOCK

| UNIT SIZE | SCREW CONVEYOR DRIVES | | | | |
|---|---|---|---|---|---|
| | RATIOS | | | | MOTOR MOUNT |
| | 4 | 9 | 14 | 24* | |
| 107J | X | X | X | X | X |
| 115J | X | X | X | X | X |
| 203J | X | X | X | X | X |
| 207J | X | X | X | X | X |
| 215J | X | X | X | X | X |
| 307J | X | X | X | X | X |
| 315J | X | | X | X | X |
| 407J | | | X | X | X |
| 415J | | | | | |
| 507J | | | | | |

½ to 40 hp. Up to 44,000 lb-in. torque

***Exclusively*** **FALK...*Single helical gears* used in *all* sizes and types—they provide maximum (98½%) efficiency per gear mesh.**

**FALK is a registered trademark**

## *New* 2 LARGER SIZES OF SHAFT MOUNTED DRIVES—415-507

**Falk-designed and Falk-built for higher torque requirements, these all-steel, *helical* gear reducers are available in Shaft and Flange Mounted Drive design.**

**TWO RATIOS, 15:1 and 25:1**
**HORSEPOWER RATINGS TO 125**
**TORQUE RATINGS TO 100,000 LB-IN.**

***Ask for*** **Bulletin 7100.1 (Shaft and Flange Mounted Drives) or for Bulletin 7106.1 (Screw Conveyor Drives).**

**THE FALK CORPORATION**
**MILWAUKEE 1, WISCONSIN**

***Manufacturers of Quality Gear Drives and Flexible Shaft Couplings***

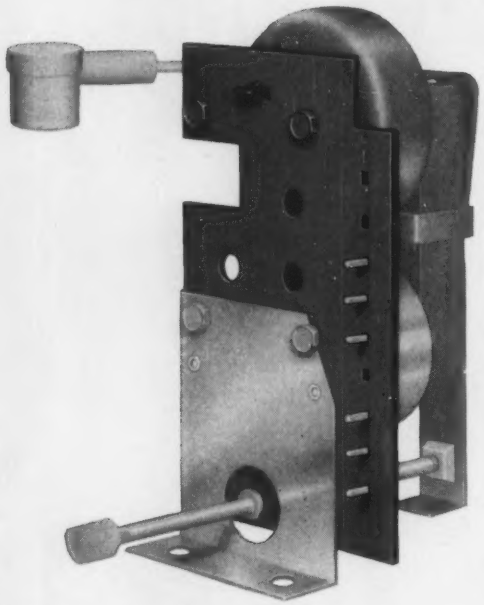
**Representatives and Distributors in most principal cities**

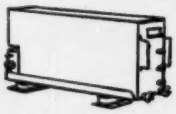
---

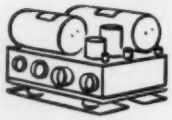
**A POINT TO PONDER... when you need gear drives or shaft couplings of "FALK OR EQUAL" quality, where but from Falk can you get the "OR EQUAL"?**

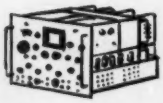
Circle 429 on Page 19

# NEW SPAULDITE XXXP-770 PHENOLIC LAMINATE COMBINES *COLD PUNCHING* AND *FIRE RESISTANCE* . . . COSTS LESS THAN PAPER EPOXIES









**TYPICAL PROPERTIES OF XXXP-770 — 1/16" Thickness**

| | |
|---|---|
| Thickness Range | 1/32 - 3/16" |
| Punching Quality | Cold |
| Shearing Quality | Cold |
| Water Absorption % | 0.65 |
| Dissipation Factor 1 MC | |
| Condition A | .029 |
| Condition D-24/23 | .034 |
| Dielectric Constant 1 MC | |
| Condition A | 4.4 |
| Condition D-24/23 | 4.6 |
| Dielectric Strength Parallel to Plys KV | |
| Condition D-48/50 | 49 |
| Rockwell Hardness M Scale | |
| Condition A | 78 |
| Flame Test D635 Inches Burned | |
| (in 2 ignitions after 28 days at 135°C) | 5/8 |

**COPPER CLAD XXXP-770**

| | |
|---|---|
| Surface Resistivity — ohms/cm sq. | |
| Condition C-96/35/9 | $1 \times 10^{13}$ |
| Peel Strength as rec'd and after solder dip | |
| lbs./in. width | 8.0 |
| Solder Blister at 500°F Seconds | 15.0 |

**Because** Spaulding can fabricate XXXP-770 with lower cost cold punching methods, this new phenolic laminate offers you greater savings and efficiency in the design and production of high volume electronic parts that require self-extinguishing characteristics.

**Write** for complete data on Spauldite XXXP-770 and Spaulding's other fire-resistant grades.

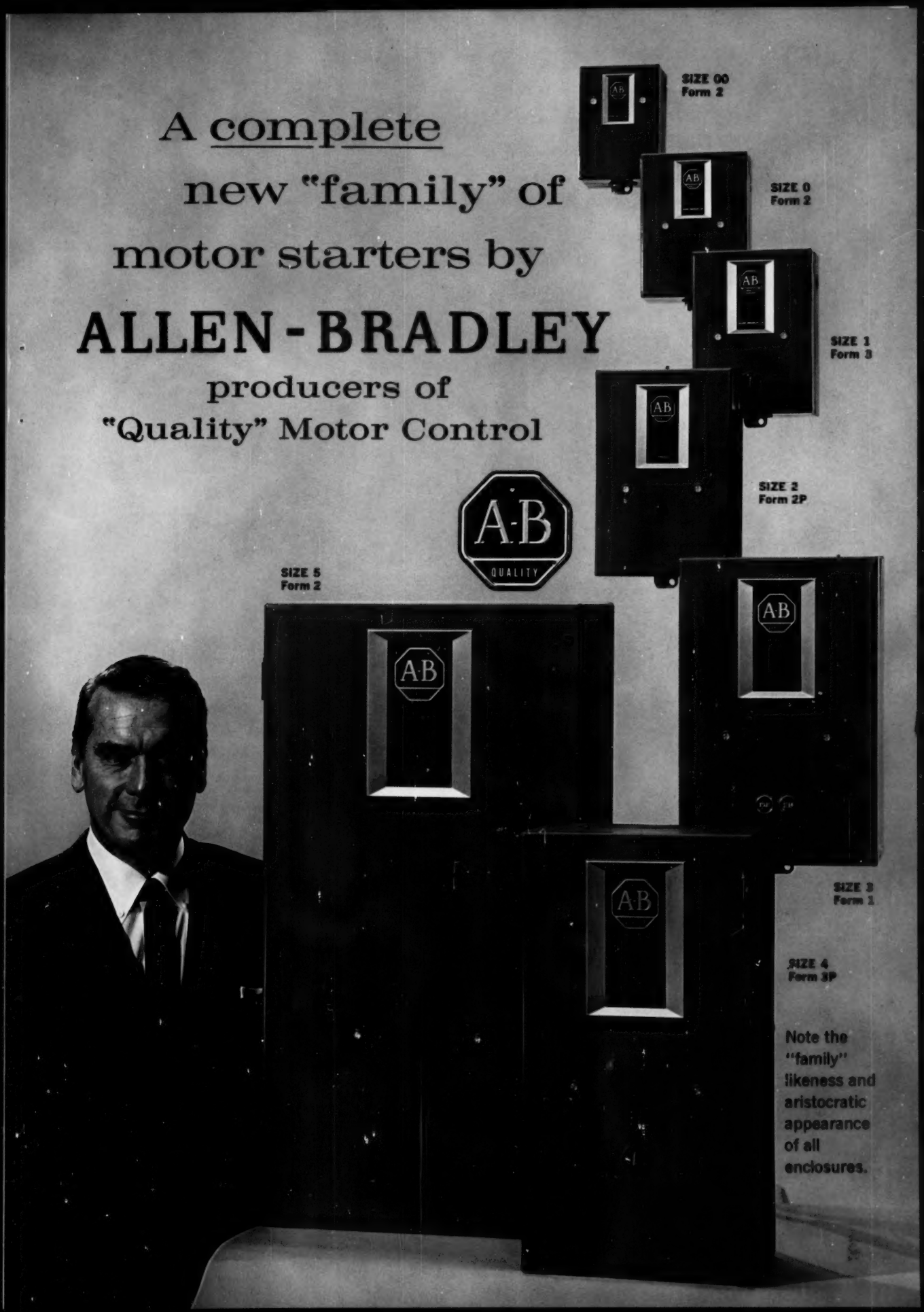
## SPAULDING FIBRE COMPANY, INC., 303 Wheeler Street, Tonawanda, New York

*See our Display at the I.R.E. Show, Booth 4216-17*



Circle 430 on Page 19

Circle 431 on Page 19→


A complete
new "family" of
motor starters by
ALLEN-BRADLEY
producers of
"Quality" Motor Control
A-B
QUALITY
SIZE 00
Form 2
SIZE 0
Form 2
SIZE 1
Form 3
SIZE 2
Form 2P
SIZE 3
Form 1
SIZE 4
Form 3P
SIZE 5
Form 2
Note the "family" likeness and aristocratic appearance of all enclosures.

# Greatest advance in motor

***PLUS VALUES OF THESE NEW STARTERS***

- smaller size
- greater interrupting capacity
- even more millions of trouble free operations
- more wiring room
- elegant styling
- A-B "quality" throughout

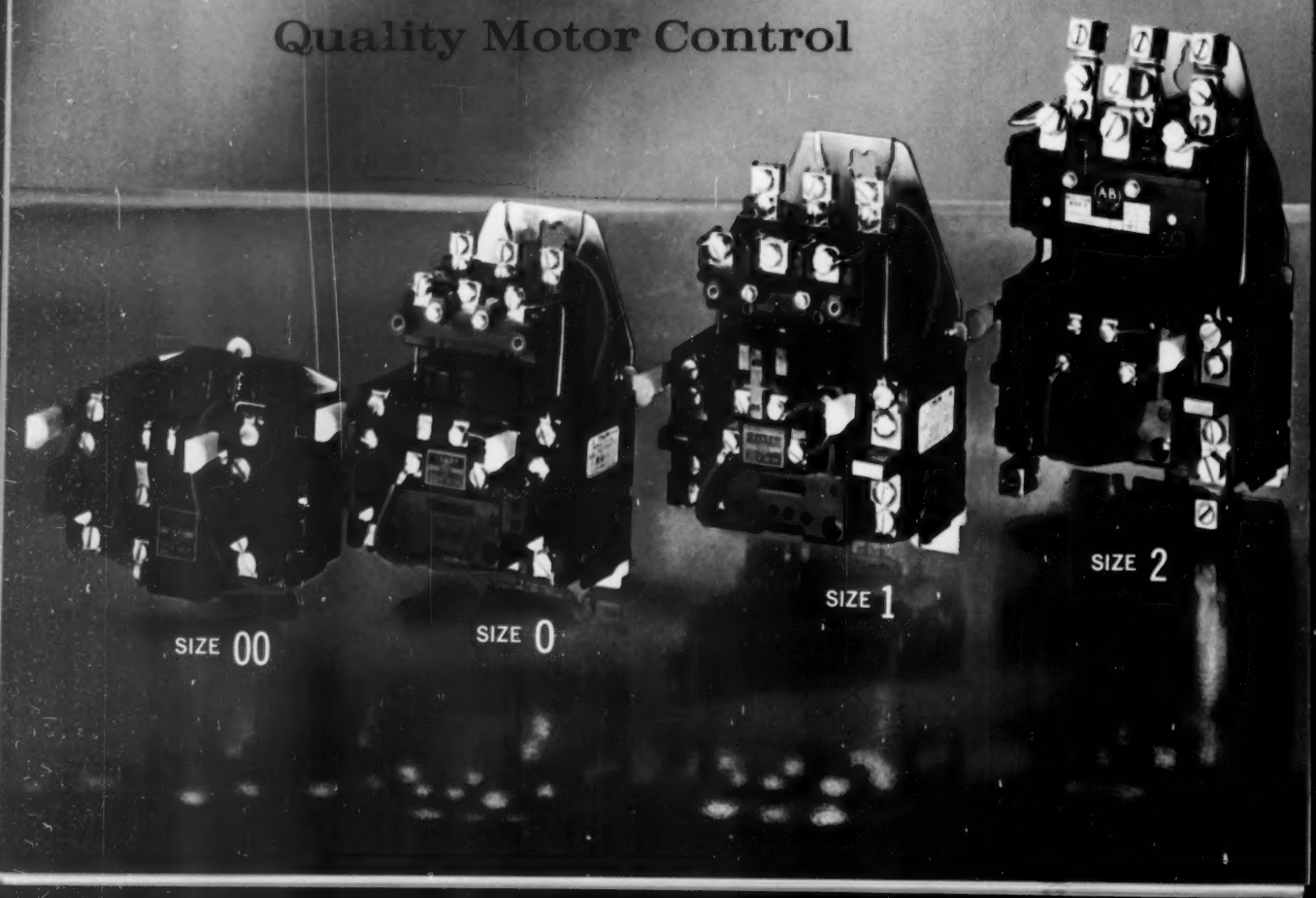
**Thirty years of experience have gone into the design of this new Allen-Bradley line of motor starters.** While retaining the principle of the simple solenoid design—with only ONE moving part—everything about these Bulletin 709 starters is **new**.

They're small—especially in the higher ratings. Yet, size for size, all tests have proved that they will outlast any starter now on the market —many times.

The **new**, patented, high-efficiency magnet—remarkably powerful for its weight and size—is cushioned to reduce shock and wear. The **new** coil is encapsulated for mechanical protection, and cannot be damaged by any corrosive atmosphere in which it may be used. The **new** precision hot molded arc hood confines the arc and increases the interrupting capacity.

## ALLEN-BRADLEY

Bulletin 709
Quality Motor Control

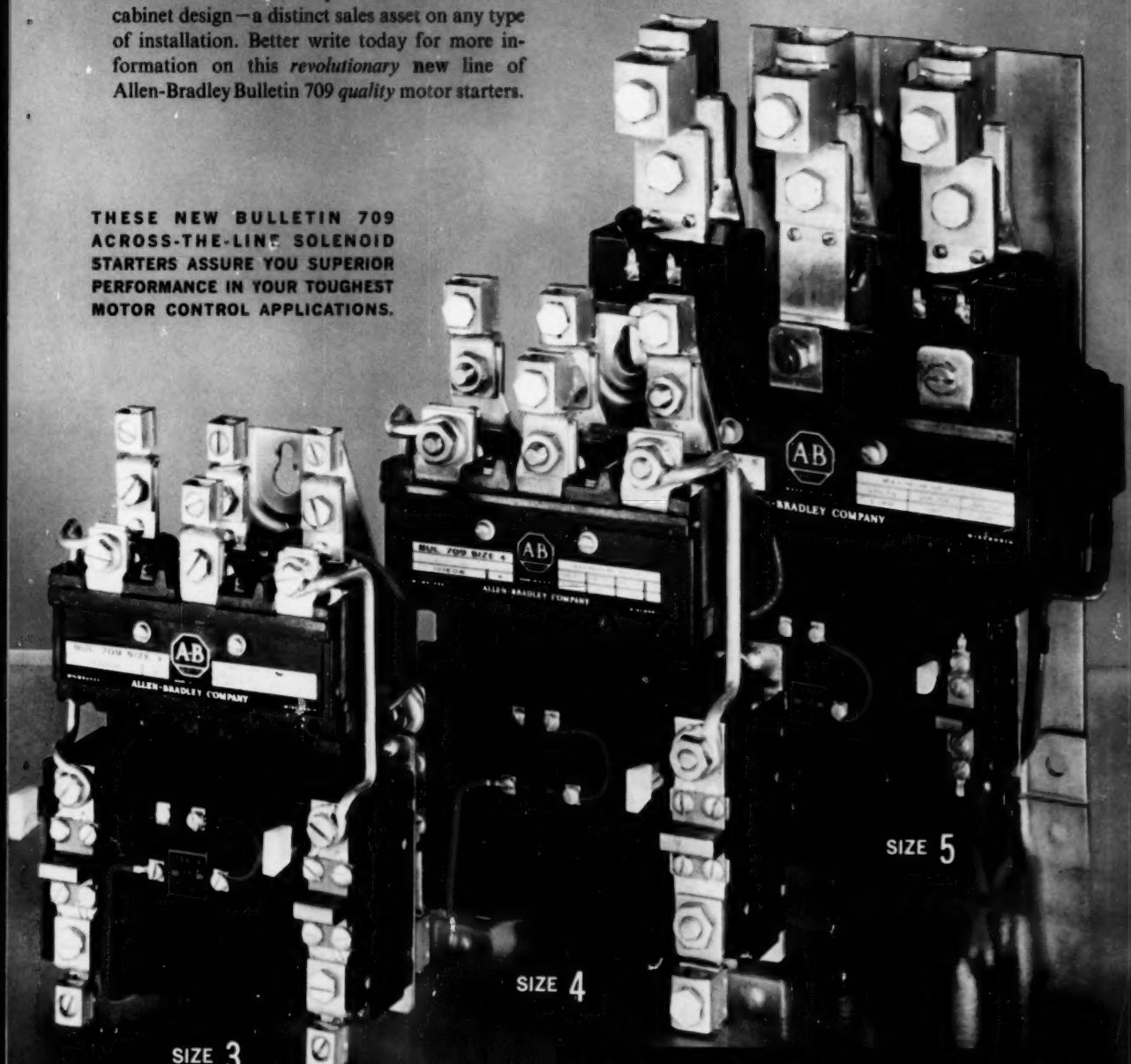


# control...in 30 years!

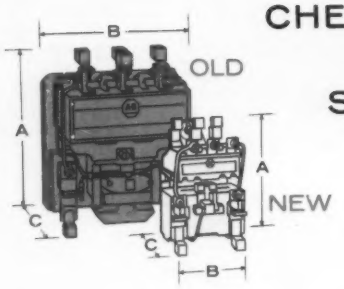
New weld-resistant, cadmium oxide silver contacts close and seat firmly, eliminating the sliding motion that causes wear. The overload relays are also **new** and are not only completely *trip-free* but also *tamperproof*. Of course, they were designed to use the **old** Bulletin 709 heating elements you have in stock.

Brooks Stevens is responsible for the smart cabinet design—a distinct sales asset on any type of installation. Better write today for more information on this *revolutionary* **new** line of Allen-Bradley Bulletin 709 *quality* motor starters.

**THESE NEW BULLETIN 709 ACROSS-THE-LINE SOLENOID STARTERS ASSURE YOU SUPERIOR PERFORMANCE IN YOUR TOUGHEST MOTOR CONTROL APPLICATIONS.**

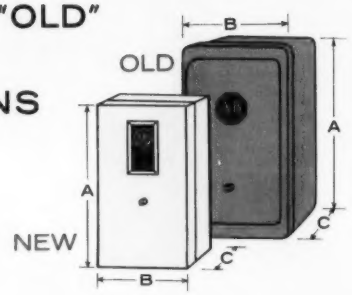



Note, also, the "family" likeness of all open type starters. Imagine the beautiful "special panel" engineering that can be done with this A-B family of starters, contactors, and relays.




# CHECK THE "NEW" WITH THE "OLD" BULLETIN 709 SPACE-SAVING DIMENSIONS

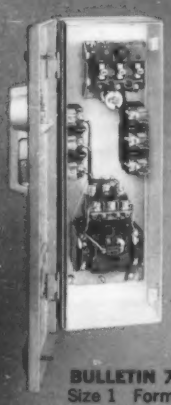
The wiring room in the new enclosure will delight the electrician.



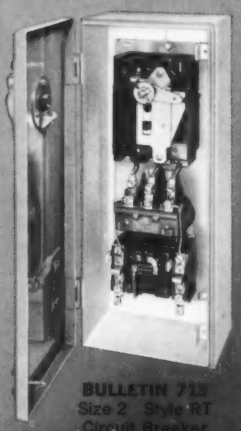

**TOTAL OVER-ALL DIMENSIONS**

| Starter Size | OPEN TYPE STARTERS | | | | | | NEMA 1 ENCLOSURES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NEW | | | OLD | | | NEW | | | OLD | | |
| | Height A | Width B | Depth C | Height A | Width B | Depth C | Height A | Width B | Depth C | Height A | Width B | Depth C |
| 00 | 3 5/8 | 3 7/8 | 3 9/16 | — | — | — | 7 5/8 | 4 7/8 | 4 1/4 | — | — | — |
| 0 | 5 7/8 | 4 1/16 | 3 1 1/16 | 5 5/8 | 4 3/4 | 3 1/4 | 9 1/8 | 6 5/16 | 4 3/8 | 7 7/8 | 5 5/8 | 4 1/4 |
| 1 | 6 5/8 | 4 1/2 | 3 1 1/16 | 5 7/8 | 5 | 3 1/4 | 10 | 6 1 3/16 | 4 3/8 | 8 1 3/16 | 6 3/8 | 4 1/4 |
| 2 | 7 3/4 | 4 5/8 | 3 1 1/16 | 10 1/16 | 5 3/4 | 4 7/32 | 12 | 7 5/8 | 4 3/8 | 14 1/2 | 9 | 5 7/16 |
| 3 | 10 1/4 | 6 1/4 | 5 7/16 | 12 5/8 | 7 1/4 | 5 7/16 | 16 5/8 | 10 3/8 | 7 | 19 1/2 | 11 3/8 | 6 1 1/16 |
| 4 | 11 7/16 | 7 5/16 | 6 1/4 | 16 1/4 | 12 3/4 | 6 1 5/16 | 22 | 11 5/8 | 8 | 26 9/16 | 14 3/16 | 7 1 1/16 |
| 5 | 14 1 3/16 | 9 | 6 1/2 | 20 | 16 1/8 | 8 3/4 | 32 3/16 | 17 3/16 | 9 7/8 | 41 1/2 | 19 9/16 | 13 3/16 |

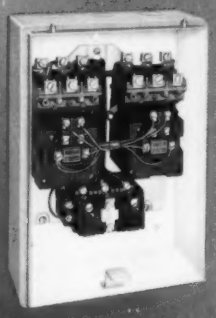
## Also...other across-the-line starters in the NEW A-B design!



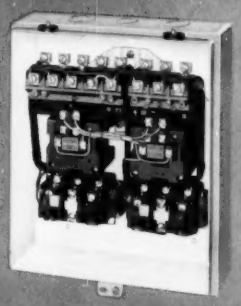
**BULLETIN 712**
Size 1 Form 2F
Fused Disconnect



**BULLETIN 713**
Size 2 Style RT
Circuit Breaker



**BULLETIN 705**
Size 1 Style RT
With Overload Relays



**BULLETIN 715**
Size 1 Two Speed
Consequent Pole

# ALLEN-BRADLEY

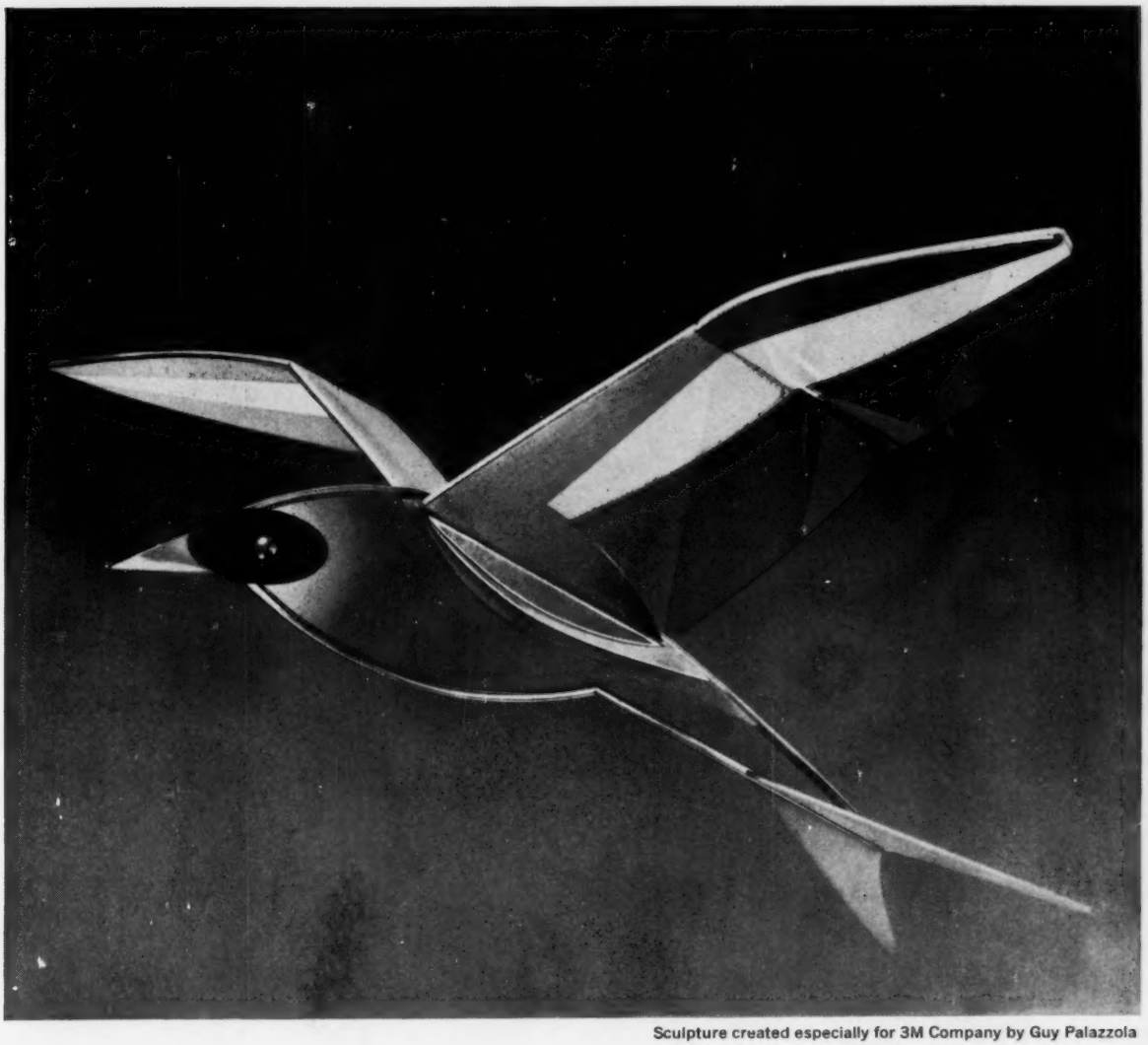
Member of NEMA

*Quality Motor Control*

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wisconsin

A-B QUALITY

9-61-RM



Sculpture created especially for 3M Company by Guy Palazzola

# FEATHER-LIGHT...

## 3M Adhesives help take pounds off today's metalworking products

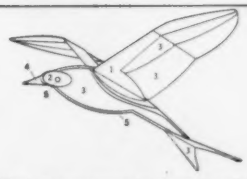
Reducing dead weight can give a product extra sales advantages . . . make it easier to handle and assemble . . . lower shipping and production costs. The answer: Fabricate with 3M Industrial Adhesives and save weight without sacrificing strength.

In fact, 3M Adhesives often substantially increase the strength of an assembly by distributing stresses evenly over a wide area, making lightweight, high-strength designs possible. And without mechanical fasteners that lower the integrity of the material and cause stress points that tear, fabricators can substitute lighter gauge materials.

For example, 3M Adhesive EC-1357—only one of a complete line of strong, general purpose industrial adhesives—finds wide application in products requiring strength and light weight. It is used in the bonding of metal frames to veneered plywood . . . in honeycomb construction for table tops . . . in sandwich-type wall panels, where it bonds porcelain enameled steel to an expanded glass core.

Backed by a quarter century of research, 3M Technical Service is solving fabrication problems for leading manufacturers in various industries. For an accurate appraisal of how an adhesive can add strength, light weight, production economy, and greater design freedom to your process or product, look first to 3M. Write AC&S Division, 3M Company, Department SBR-31, St. Paul 6, Minnesota.





**What do you want to bond to what?**

The Bird is fabricated of these materials and bonded with a variety of 3M Adhesives:

1. Stainless Steel 2. Wood 3. Plastic 4. Glass 5. Brass.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

←Circle 431 on Page 19

Circle 432 on Page 19

# Tool and Hardware Manufacturers Use Malleable for the Parts They Guarantee...

"Guaranteed Against Warping or Breaking" is the seal of quality often found on tools and hardware made of Malleable iron. Frequently Malleable components are guaranteed while the other materials in the same tools are not.

Proven performance superiority has induced many tool and hardware manufacturers to switch to Malleable castings so they, too, can guarantee their products. At the same time, they often reduce their costs. How? Because Malleable provides more strength per dollar than any other metal; Malleable is the most machinable of all ferrous metals of similar properties; Malleable is truly outstanding for its toughness, ductility, castability and corrosion resistance. While Malleable's natural appearance is attractive, a wide variety of finishes can be applied for added customer appeal.

Improve your products by using Malleable castings. Check with any Malleable producer that displays this symbol —

MEMBER

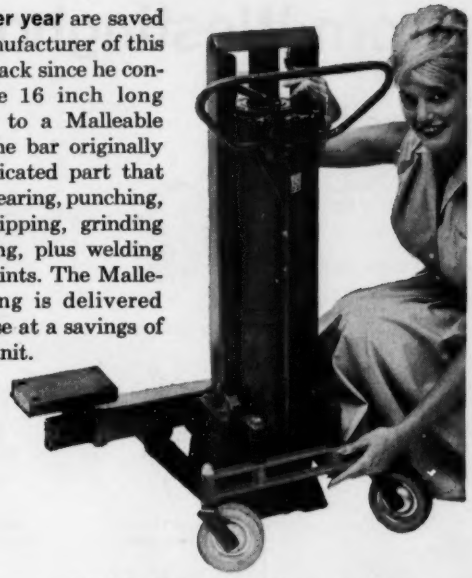
MALLEABLE

CASTINGS COUNCIL

**Profitmaking Ideas** are yours free in our Data Unit No. 114, available from any member foundry, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

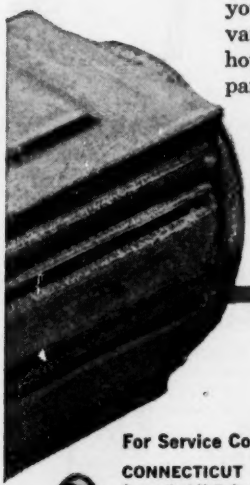
The manufacturer of this unit converted his entire line of machinist vises to Malleable... then guaranteed them against breakage. Not one claim has been made in three years!

**$10,000 per year** are saved by the manufacturer of this hydraulic jack since he converted the 16 inch long caster bar to a Malleable casting. The bar originally was a fabricated part that required shearing, punching, sawing, chipping, grinding and reaming, plus welding at eight points. The Malleable casting is delivered ready-to-use at a savings of $2.68 per unit.



The wide range of Malleable's properties permits its use in hundreds of tool and hardware applications. Besides the examples shown here, Malleable is used for load binders, chain hoists, hinges, many kinds of clamps, pliers, trailer hitches, jack screws, gun frames, fence fittings, casters, brackets and pipe threading and cutting tools.

When you're interested in high quality and long life, Malleable gives your products many competitive advantages. We'll be glad to show you how. Write or call one of the companies listed below.





## For Quality and Economy...Use

MALLEABLE

**For Service Contact...**

**CONNECTICUT**
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck

**DELAWARE**
Eastern Malleable Iron Co., Wilmington 99

**ILLINOIS**
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Iron Works, Moline
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

**INDIANA**
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

**IOWA**
Iowa Malleable Iron Co., Fairfield

**MASSACHUSETTS**
Belcher Malleable Iron Co., Easton

**MICHIGAN**
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

**MINNESOTA**
Northern Malleable Iron Co., St. Paul 6

**MISSISSIPPI**
Mississippi Malleable Iron Co., Meridian

**NEW HAMPSHIRE**
Laconia Malleable Iron Co., Laconia

**NEW YORK**
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

**OHIO**
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Mall. and Steel Castings Co., Cleveland 6

**PENNSYLVANIA**
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

**TEXAS**
Texas Foundries, Inc., Lufkin

**WEST VIRGINIA**
West Virginia Mall. Iron Co., Point Pleasant

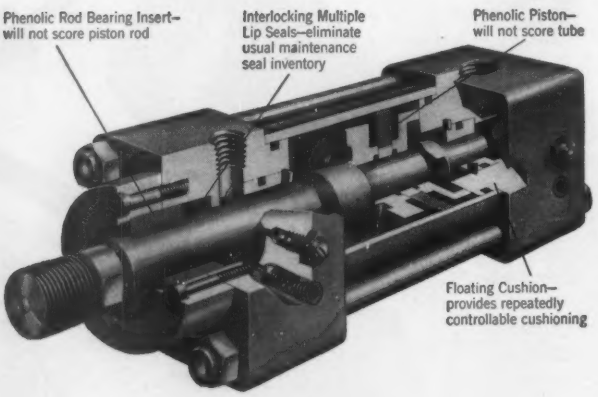
**WISCONSIN**
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46


Circle 433 on Page 19

# Fluid Circuitry News from Westinghouse

## Industrial Product Division expands line

The Petch line of high quality air and hydraulic cylinders is now part of the line of Westinghouse Fluid Circuitry components. This acquisition makes it possible for us to offer industry the *most complete line* of air and hydraulic components for control systems to automate industrial production operations.




The Petch line of rugged, precision made cylinders include the following models:

**Air & Low Pressure Hydraulic Cylinders**

150 psi Air 500 psi Hydraulic
1″ to 10″ Bores
10 Standard Mountings

**High Pressure Hydraulic Cylinders**

1½″ to 6″ bores—2000 psi
8″ to 10″ bores—3000 psi
10 Standard Mountings

All Petch Cylinders conform to J. I. C. Standards.

### FLUID CIRCUITRY... FOR TROUBLE-FREE AUTOMATION

Fluid Circuitry is the application of fluid control systems to industrial production operations.

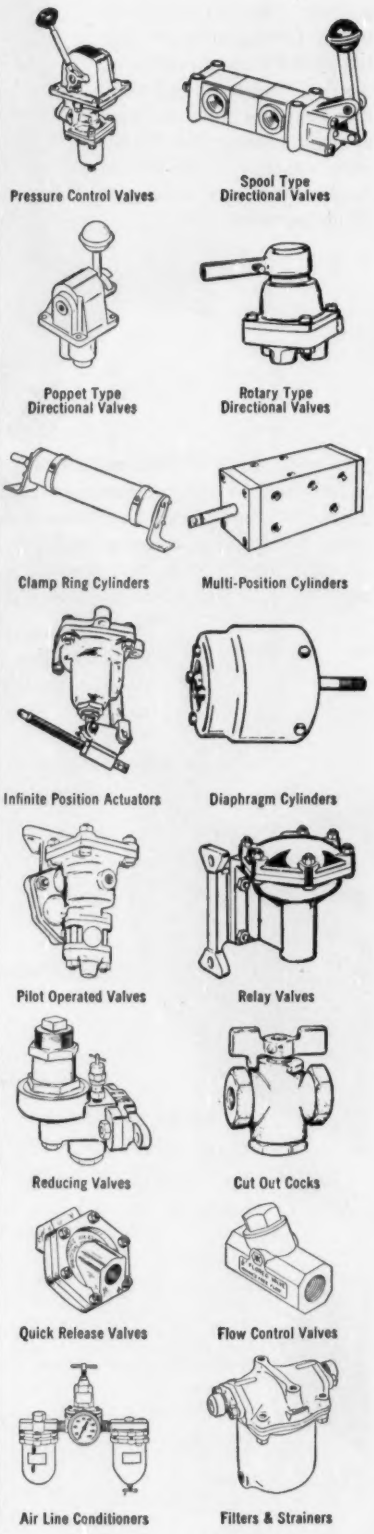
Fluid Circuits are economical, safe and precise. They are used to solve the most vigorous and complex control problems.

They contain reliable products to boost your production and cut your production costs.

For more information on Petch Cylinders and Fluid Circuitry ask for catalog A3-56.00.

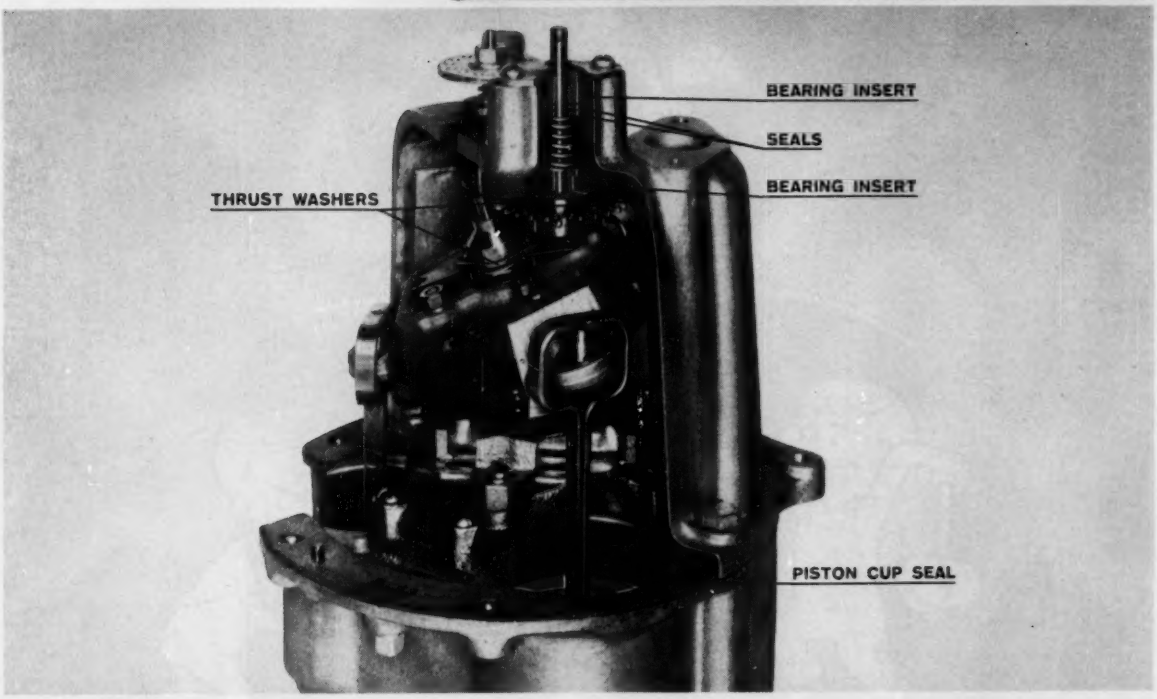
*See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.*

**WESTINGHOUSE AIR BRAKE COMPANY**
INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA



DU PONT

# TEFLON®




# Non-lubricated seals and bearings made with TEFLON® give maintenance-free service in gasoline-pump meter

## CAN YOU AFFORD NOT TO USE TEFLON®?

Seals and bearings of TEFLON resins are your logical and most economical choice whenever problems of corrosion or lubrication are encountered, AND whenever you want—

. . . functional reliability and greatly increased service life

. . . reduced costs of replacement, maintenance and downtime

. . . greater standardization with reduced inventories

. . . the competitive advantage of quality and dependability

If any of these considerations are important to your design, the choice of any other seal or bearing materials might well be wasteful.

DU PONT
REG. U. S. PAT. OFF.

This new pump meter is built for maximum reliability—designed to withstand the effects of additives in gasolines. The drive rod seals, piston cup seals, sleeve bearings and thrust washers are made with filled compositions of Du Pont TEFLON fluorocarbon resins. TEFLON resins were specified in these vital parts because they have the lowest coefficient of friction of any solid material and are not affected by gasoline.

The zero-leak seals made with TEFLON require no lubrication. They will not age or harden . . . do not require any maintenance. The bearings offer similar maintenance-free performance.

The simplicity and dependability of seals and bearings made of TEFLON resins open a wide variety of opportunities for improved design. It will pay you to investigate the functional improvements and cost savings made possible with TEFLON. For more information, write to: E. I. du Pont de Nemours & Co. (Inc.), Dept. MD-330, Room 2526T, Nemours Bldg., Wilmington 98, Del.

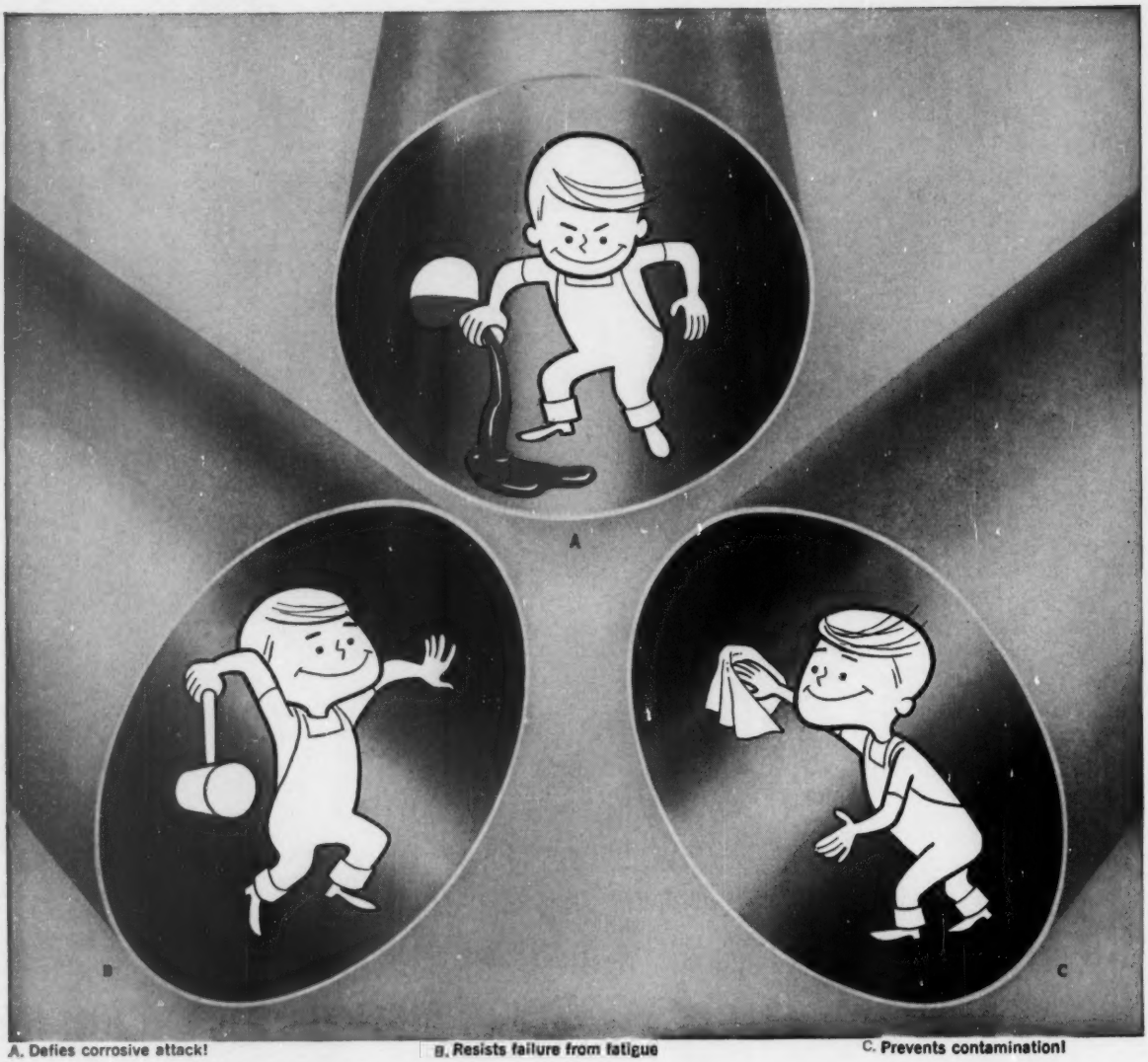
**In Canada:** Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

**TEFLON®**
**FLUOROCARBON RESINS**

*TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*


Circle 435 on Page 19




A. Defies corrosive attack! B. Resists failure from fatigue C. Prevents contamination!

## The "Gravity Kid" shows how
# ONLY CONTOUR-WELDING COMBINES ALL THREE BENEFITS IN A SINGLE TUBE

Feel the inside surface of a Contour-welded* stainless tube. It's so smooth you barely feel the weld. Even with a microscope you see fewer crevices and flaws than you find in other makes of tubing. This smoothness is exactly the reason why Contour-welded tubing is so resistant to corrosive attack...to product incrustation ...and to failure from fatigue.


Contour-welded tubing is smoother than other tubing, welded or seamless, because it's welded at the bottom. Gravity pulls the metal down so that the weld corresponds to the inside contour of the tube. There's no bulge on the inside surface. Even on the outside surface, the seam closely conforms to the tubing shape.

Just the opposite occurs in conventionally-welded tubings. There, gravity pulls the molten metal down into the tube. This can form a bead that is difficult to remove by cold working. And cold working can lead to undercuts that become focal points for corrosive attack, incrustation, and even failure from fatigue.

Contour-welded tubing is smoother than seamless. That's because it's formed from uniformly rolled strip steel, whereas seamless must be produced by extruding or piercing.

But get the full story. Write today for our free 48-page manual, which describes tubing sizes from 1/8" to 40" O.D., in stainless and high alloy steels, titanium, zirconium, zircalloy, and Hastelloy**.

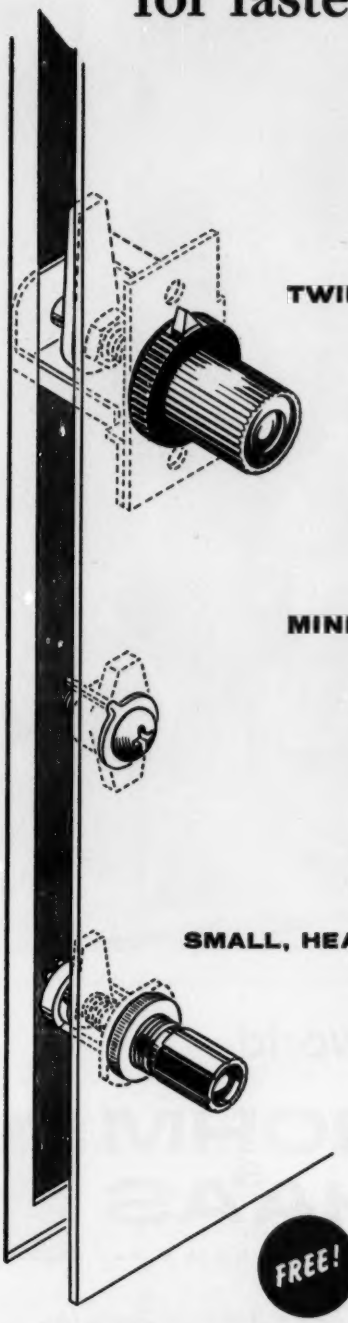
*Trent's patented process — U.S. Patent 2,716,692

**Trademark Haynes Stellite Co.

## TRENTWELD® Stainless and High Alloy Tubing

Trent Tube Company, a Subsidiary of Crucible Steel Company of America, General Offices and Mills: East Troy, Wisc.; Fullerton, Calif.

# Standards with unique features for fastening doors and panels

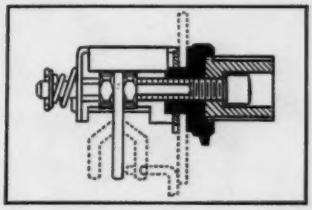


*Southco adjustable pawl fasteners are easy and economical to install, give a "class" appearance to equipment. They apply controlled pressure to seal tightly and stop rattles.*

## TWIN KNOB CONTROL—NO. 46

The pawl engages the frame when the actuator is turned 90°. A bright chrome button in the center of the knob is preset for the amount of pressure to be exerted by the fastener. After the pawl engages the frame, the knob is turned until the button is flush with the knob surface. Preset pressure is thus obtained.

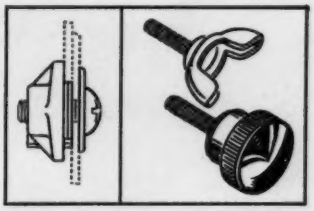
Materials *Body: Cadmium plated steel*
*Knob: Black nylon*



## MINIATURE ENVELOPE—NO. 45

Requiring a minimum of space inside and outside, this fastener latches on a 1/4 turn and additional turning pulls up the door or panel against its frame. The nylon pawl operates smoothly against metal and provides exceptional wearing qualities.

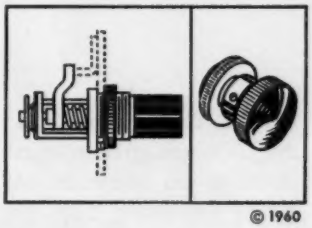
Materials *Pawl stop and washers: Carbon steel, cadmium plated*
*Pawl: Nylon, natural*



## SMALL, HEAVY-DUTY MOUNTING—NO. 48

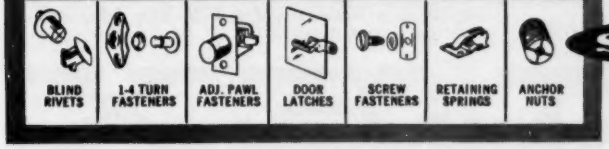
Small, rugged, compact. One quarter turn closes, additional turning tightens. Quickly installed with a single mounting nut. Three sizes cover every frame thickness from .000 to .750. Can be supplied with flatted shaft for your knob.

Materials *Body and pawl: Steel, cadmium plated*
*Knob: Black nylon*





FREE! **Your copy of Southco Fastener Handbook containing engineering data on wide selection of fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.**




SOUTHCO FASTENERS
LION

*Johnson reel (Denison-Johnson Corp.); Imperial 8 radio (Admiral Corp.); Aqua Hone sharpener (Sun Enterprises, Inc.)

# IMPLEX in a man's world

IMPLEX, the high impact acrylic, goes where the tough jobs are . . . where great strength and rigidity, plus resistance to staining, are important selling points for a product. The fishing reel cover, transistor radio case and water-powered knife sharpener housing shown above* have rugged durability because they are molded of IMPLEX. This Rohm & Haas molding material also provides an attractive appearance by imparting high surface gloss and rich colors. Our design staff and technical representatives will be pleased to help you use IMPLEX for your present and prospective products—to your advantage. Just write and tell us about a specific project.

ROHM & HAAS

PHILADELPHIA 5, PA.

**In Canada:** *Rohm & Haas Co. of Canada, Ltd., West Hill, Ontario*

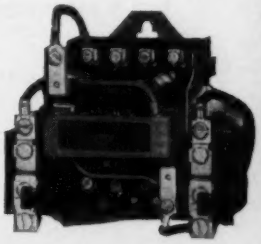
IMPLEX *is a trademark, Reg. U.S. Pat. Office and in principal foreign countries*

IMPLEX

Height over terminals of General Electric Size 1 magnetic starter is only 4 ½ inches—shortest of all leading makes.

## Measure the Space Savings Yourself

This General Electric Size 1 Magnetic Starter saves as much as two inches of panel space, compared to other leading makes. Using these smaller G-E starters, you can reduce your panel sizes, with resultant savings in labor and material costs. It is often possible to use a standard enclosure where previously a larger, more costly special was required; or to make the panel an integral part of the machine instead of mounting it separately. Your G-E sales representative or distributor can show you other MEASURABLE ADVANTAGES of G-E magnetic starters. Call him soon, or write for Publication GEA-7020. Section 811-16, General Electric Company, Schenectady, N. Y.



*Progress Is Our Most Important Product*

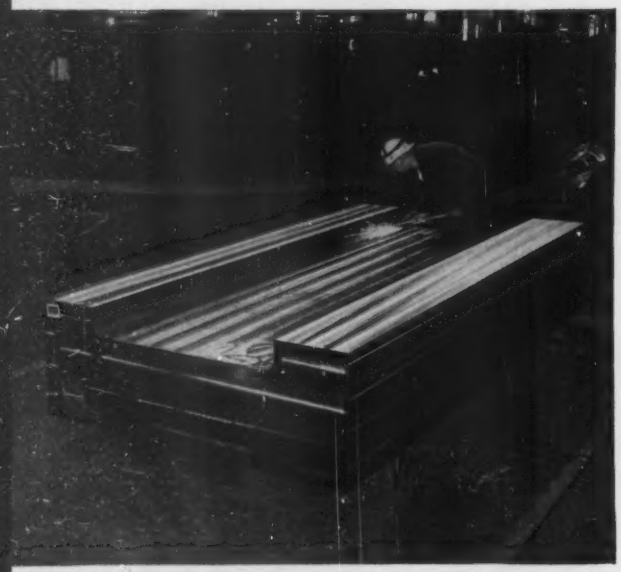
GENERAL ELECTRIC

Circle 439 on Page 19

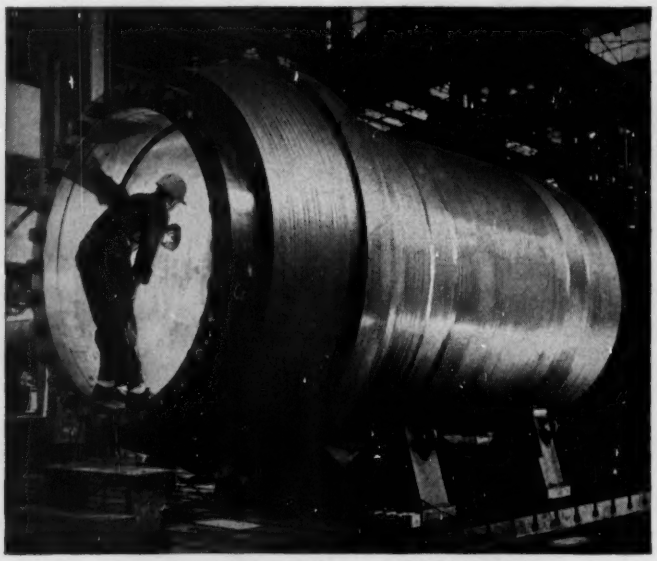
# You name it...we'll forge it!

**RIGHT ON THE NOSE. Bethlehem meets your specifications exactly on all types of press, drop, and hammer forgings.**

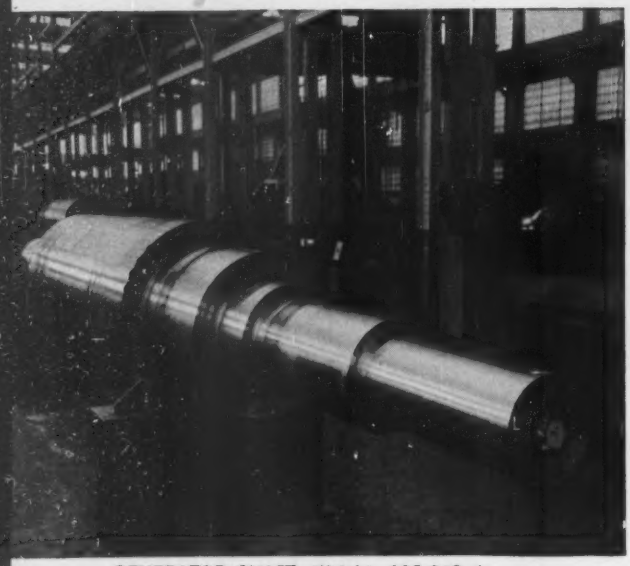
*for Strength*
*... Economy*
*... Versatility*



RAM ADAPTER. This forging weighs 58,780 lb, and measures 140 in. x 73 in. x 25 in.



STEEL CYLINDER for use in 7,500-ton plate stretcher. This forging weighs 171,240 lb, and it's 17 ft, 3 in. long.



GENERATOR SHAFT. Weight, 198,240 lb. As you can tell from these photos, Bethlehem is well-equipped for machining.

REACTOR VESSEL CLOSURE. The OD of this 50,660-lb forging measures 12 ft.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

**BETHLEHEM STEEL**

*Circle 440 on Page 19*


# HYDRECO
*out front in . . .*
# PRECISION MANUFACTURING

. . . JUST ONE MORE WAY HYDRECO SERVES YOU BETTER! The heart of Hydreco is its manufacturing operation. Hydreco's modern plant is equipped with the latest in precision machine tools and quality control equipment. Extreme care has been taken in the arrangement of departments and machines to assure a fast, smooth flow of material through the plant. And the thoroughly modern manufacturing techniques used in assembly guarantee dependable, quality products that will perform as rated.

In short, this new manufacturing operation provides the most efficient production facilities and flow for the manufacture of hydraulic equipment. It's one of several ways in which Hydreco serves you better!

**HYDRECO®** DIVISION
THE NEW YORK AIR BRAKE COMPANY
KALAMAZOO • MICHIGAN


PUMPS


VALVES


MOTORS


Circle 441 on Page 19

**OHIO** *Round Tubing*
*To 7-1/2" OD x .375" wall*

A-3673A

**OHIO** *Square Tubing*
*To 6" x 6" x .259" wall*

**OHIO** *Rectangular Tubing*
*To 7-1/2" major diameter x .259" wall*
*Typical 4" x 6" x .259" wall section illustrated*

*Announcing* Mechanical — Pressure — Cold Drawn

# OHIO QUALITY WELDED STEEL TUBING

## *in larger sizes...heavier wall thicknesses*

**OHIO SEAMLESS TUBE**

*Division of Copperweld Steel Company* • **SHELBY, OHIO**

*Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging*

New sizes and heavier wall thicknesses of Ohio Quality Welded Steel Tubing (up to 7½" OD) now parallel the sizes of famous Ohio Seamless Steel Tubing. That means — now more than ever — there's a type and size of Ohio tube to fit your special requirements exactly. And since we make both types, we're in a position to recommend the best type for your own particular needs. Ohio Tubing — either welded or seamless — is just "made to order" for your product.

Circle 442 on Page 19

*Cut along line and send air mail to save time.*

**RUSH** me, without obligation, latest information on new larger sizes and heavier wall thicknesses of Ohio Welded Steel Tubing.

Name_____ Title_____

Company _____

Address_____ City_____ State_____

# SILENCE...

## Lead at work!

Chalk up one for lead when it comes to a genuine genius for isolating sound. That's because, thickness for thickness, lead is 13 times more effective at blocking sound transmission than the next best commonly used construction material... up to 24 times more effective than some others.

And lead's characteristic density and limpness also make it stack up better pound for pound.

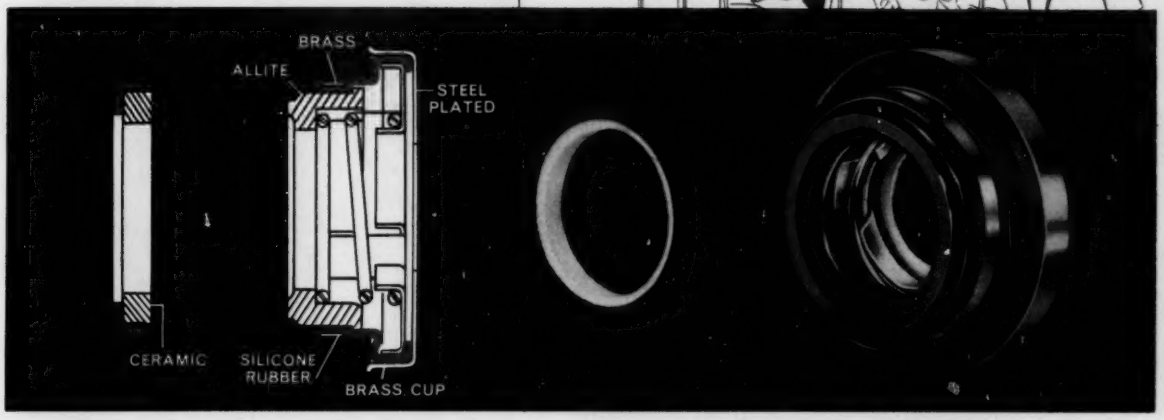
Lead gets an "A" for conduct and cooperation, too. It's tackable, paintable, fireproof and malleable—folding or bending to "dress" even over complicated surfaces. It is applicable to buildings, machinery, transportation equipment and almost every area where sound control is a problem.

LOOK AHEAD WITH LEAD

Technical data and charts prepared by the acoustical consulting firm of Bolt, Beranek and Newman are all contained in this brochure.

For your copy of the new 12-page report, *Improved Sound Barriers Employing Lead*, write to Lead Industries Association, 292 Madison Ave., New York 17, N. Y.

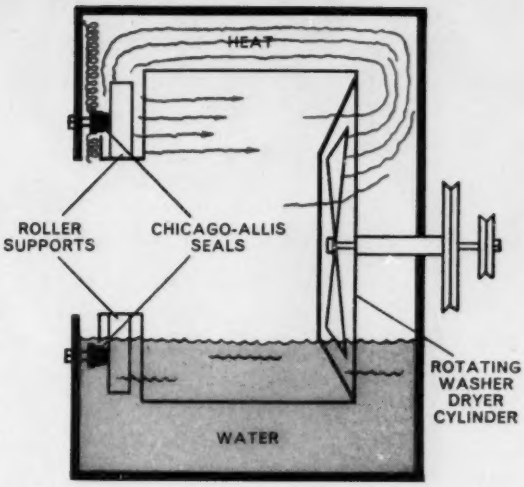
# Happy wash days depend on round the clock sealing action




## CHICAGO-ALLIS SEAL DESIGN RESISTS HEAT, WATER, SOAP, DETERGENTS AND DIRT... SEALS GREASE IN ROLLER BEARINGS FOREVER

When assigned the engineering task of designing a lifetime seal for a nationally known washer-dryer machine product, Chicago-Allis came up with the right answer pronto. The C-A seal protects bearings in rubber rollers which support the rotary washer-dryer cylinder. Rubber component parts in the C-A seal are molded of silicone and resist heat up to 240° F. Spring loading of the surface sealing elements (Allite and Ceramic), creates a life-long water and grease tight seal.

A typical example of how Chicago-Allis meets specialized needs in mechanical seals and custom molded rubber parts.




Four mechanical seals are used in this washer-dryer application—two of which must operate *under water* during the washing cycle, and all are exposed to extreme heat during the drying cycle.

Send for complete information on all Chicago-Allis products and services.

*"Chicago-Allis Engineers to your Specifications"*

SINCE 1899

**CHICAGO-ALLIS MFG. CORP.**

Producers of CHICAGO BELTING · ALLIS RUBBER · ALLIS SEAL Products

127 NORTH GREEN ST. · CHICAGO 7, ILLINOIS

*Engineers · Designers · Manufacturers*


**Zero burnout time and minimum "haloing"** are combined in CDF's new grade 614 glass fabric epoxy laminate at no increase in price over conventional NEMA G-10 grades. Available plain or copper-clad, 614 is a cold punch material that is also superior in flame retardancy, has excellent trichloroethylene vapor resistance and low moisture absorption. The grade is distinguished by its opacity and its tan color.

**Result:** Another example of CDF leadership in meeting critical military and industrial applications while effecting important customer savings!

**Typical properties of 614** (1/16" thickness):

| | |
|---|---|
| Burnout Time, sec. | 0 |
| Water Absorption | 0.10 |
| Flexural strength, psi, lw | 75,000 |

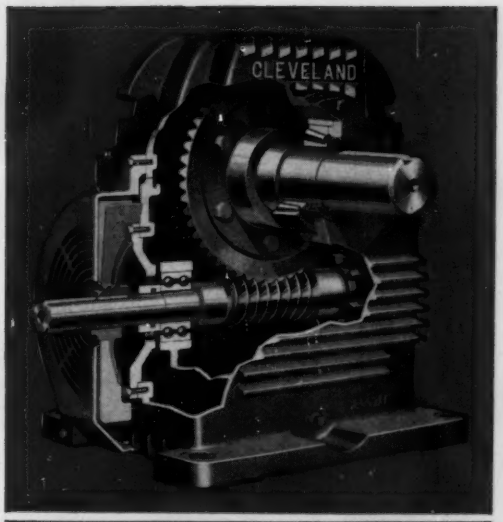
(Copper-clad 614 meets MIL-P-13949B, Type GF Plain meets NEMA G-10; approval pending for MIL-P-18177B, Type GEE. Also pending under NEMA proposed FR-4)

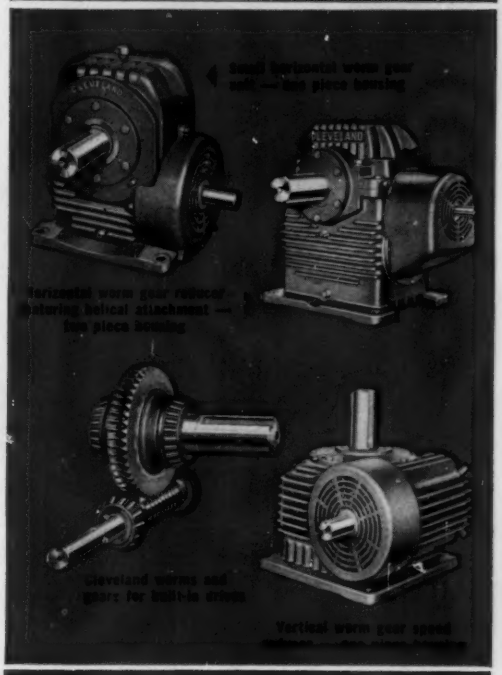
CDF CONTINENTAL-DIAMOND FIBRE

CONTINENTAL-DIAMOND FIBRE CORPORATION, NEWARK, DELAWARE • A SUBSIDIARY OF THE Bird COMPANY

## *for smooth, quiet, dependable, right-angle power transmission, specify...*

# HIGHER HP CLEVELAND SPEED REDUCERS



During a lifetime of trouble-free service, these versatile space-saving Cleveland's will transmit power uniformly, smoothly, dependably—under even the most severe operating conditions. Clevelands actually improve through use. Thousands of units have outlasted their driven machines.

During the last half century, Cleveland has designed and produced a complete line of standardized and special worm gear speed reducers as well as industrial worm gearing for built-in drives to handle almost every type of power transmission application.

Now, Cleveland's use of fan cooling, centrifugally cast bronze gears and special heat treatment of alloy steel worms permit substantially higher input HP and output torque ratings—with smaller units.

Cleveland's wide knowledge of worm gear capabilities enables their field representatives to offer valuable engineering assistance in solving power transmission problems. These experienced engineers will gladly provide you the advantage of "on location" advice and counsel.

Write today for your personal copies of the up-to-date illustrated Bulletins shown at right. They describe the finest, newly-designed line of higher-horsepower worm and gear speed reducers—available *anywhere* in the world.


**Cleveland Worm & Gear Division**
Eaton Manufacturing Company
3287 East 80th Street • Cleveland 4, Ohio

**CLEVELAND**
**Worm Gear**
*Speed Reducers*


Circle 445 on Page 19





**Also rings from: Bearing Bronze, Low Alloys, Magnesium, Zirconium and Copper Base Alloys**

# we make rings-you save money

**Today Amweld is making flash butt-welded rings** from nearly a hundred different metal alloys for over a hundred different applications. In each case the customer saves money over the cost of alternative ring making processes. He saves on metal, because Amweld forms rings from stock that is produced to or near finished dimensions. He saves on machining, because the metal is left out—not hogged out.

**Amweld customers saved over one million dollars** last year. By close cost evaluation of circular components and assemblies, flash welded rings were introduced enabling substantial savings. It doesn't cost you to think on paper with Amweld. Let us quote you for your cost comparison. Write today: The American Welding & Manufacturing Company, 902 Dietz Road, Warren, Ohio.

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INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MANUFACTURING CO., WARREN, OHIO



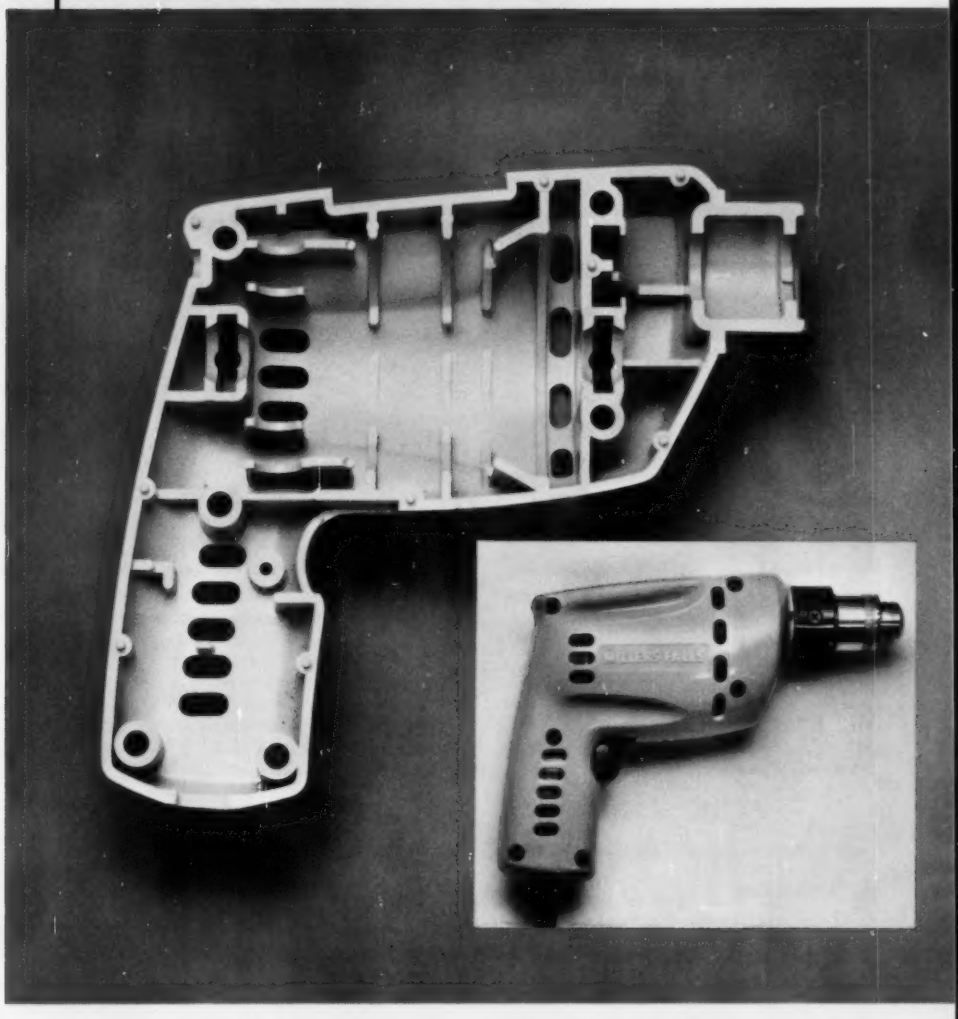
Circle 446 on Page 19

Circle 447 on Page 19→

*working with*

# Du Pont Zytel®

*one of Du Pont's versatile engineering materials*



## New drill housing of ZYTEL® NYLON RESINS insulates ...eliminates costly machining operations

A basic design advance in power tools, this ¼" drill is made with a nonconductive housing of Du Pont ZYTEL nylon resin. Double-insulated, it protects the user against shock hazard. Other design advantages include a weight saving: the housing of ZYTEL is 20% lighter than a comparable housing of aluminum. It is self-extinguishing. It stays comfortable to the touch in hot and cold weather and after prolonged use. It is rugged, durable and impact-resistant.

In addition, the use of ZYTEL affords substantial production advantages. The two halves of the drill housing, though complex in design, are quickly and easily molded. The excellent dimensional stability of ZYTEL assures a perfect match of each half for screw inserts, assembly and flange matings. And the housing requires no machining operations whatever.

Molded by Nylon Products Corp., affiliated with F. J. Kirk Molding Co., Clinton, Massachusetts, for Millers Falls Company, Greenfield, Mass.

On the following page you will find additional examples of practical design improvements made possible by the combination of properties that ZYTEL nylon resins offer.

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

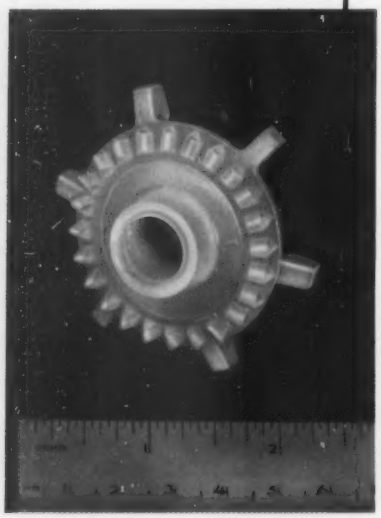
*working with*

**Du Pont Zytel®**

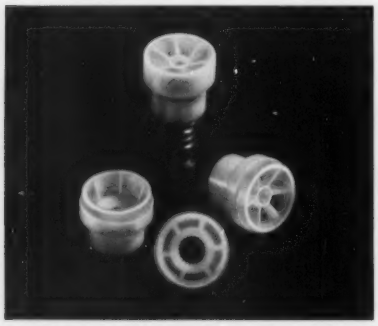
*nylon resins*

*one of Du Pont's versatile engineering materials*

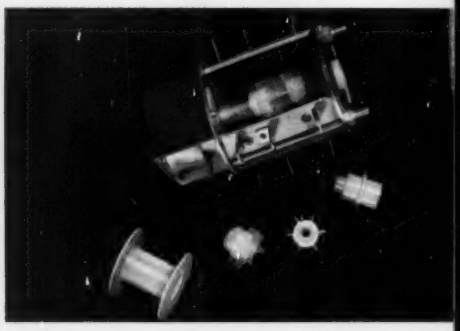
# Parts of ZYTEL® NYLON RESINS perform reliably under attack by heat, impact and chemicals



**This oil slinger** swirls oil onto vital engine parts. It must be tough, resistant to impact, abrasion and attack by oil at high temperatures. ZYTEL provides all these resistant properties and permits economical injection molding of the part. (Molded by Sinko Mfg. & Tool, Chicago, Ill., and Danielson Mfg. Co., Danielson, Conn., for Briggs & Stratton, Milwaukee, Wis.)



**These faucet-handle inserts** are designed for interference-fit assembly and to act as an insulator against heat. These rugged parts of ZYTEL will withstand 116 inch-pounds torque at the stem between 20° and 160°F. They are expected to give at least 20 years of efficient service. (Molded for American Radiator & Standard Sanitary Corp., New York, New York.)



**This compact switch relay** uses parts molded of ZYTEL to withstand rugged treatment and yet operate quickly, smoothly and positively. Necessary in this application are good heat resistance, good electrical properties and high strength in thin sections. ZYTEL fills the bill. (Molded by Ritepoint Pen & Pencil Co., for Warco Industries, both of St. Louis, Missouri.)

An important factor in the design versatility of ZYTEL nylon resins is their ability to be molded to accurate tolerances without costly machining. Equally important is the wide variety of ZYTEL nylon resins available to meet special problems. All ZYTEL compositions have the basic properties of low friction, impact and abrasion resistance, high strength and resistance to chemicals.

Du Pont ZYTEL may help you, too, to improve the performance or the economics of a part or product. The coupon below will bring you information relating to your own problem or field of interest.

POLYCHEMICALS DEPARTMENT

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E. I. du Pont de Nemours & Co. (Inc.), Dept. 1
Room 2507Z, Nemours Building, Wilmington 98, Delaware.

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B ☐ Designing with ZYTEL®

I am interested in evaluating ZYTEL for_____

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# NOW... Twin-Size

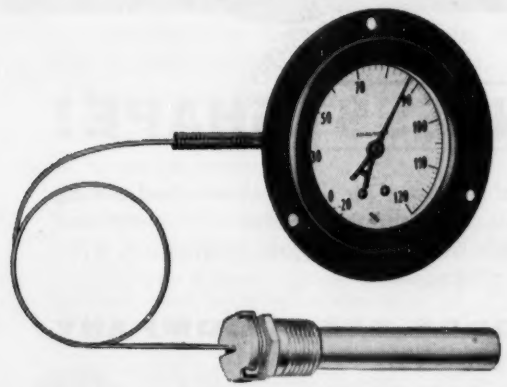
## Pressure Gauges and Thermometers for "companion" installation

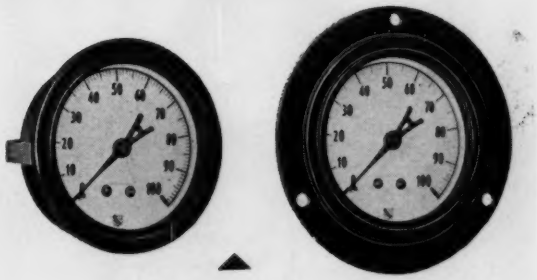
Appearance rates with high accuracy when gauges and thermometers are essential to the equipment you have "on the boards."

These size-matched pressure and temperature indicators are also similar in case, dial, and pointer design. Such "look alike" characteristics add a quality look to the design of any panel or other mounting surface.

Ashcroft Gauges and American Thermometers have a reputation for sustained accuracy and ruggedness in the most demanding power and processing industry services. Their fine quality is matched by long-term economy on all recommended applications.

Get complete technical data on these 2½" Ashcroft Gauges and American Thermometers, then select those best-suited to the equipment you are engineering. Write for Bulletin 371. Mail the coupon today.





### 2½" ASHCROFT GAUGES

**"U" Clamp and Front Flange Styles**
Steel Case: ⅛" and ¼" NPT centered back connection.

**Ranges.** Pressure: 0-15 psi to 0-600 psi. Vacuum: 0 to 30" mercury, or 0 to 34 ft. of water. Compound: 15 psi and 30" to 300 psi and 30".

**Recommended Applications:** For equipment such as portable compressors, pumps, water tanks, industrial washers, and pressure lines.

### 2½" AMERICAN THERMOMETERS

**"U" Clamp and Front Flange Styles**
Vapor pressure actuation. Steel case. Plain bulb; or cadmium-plated steel well for corrosion protection.

**Ranges.** Fahrenheit: Ranges from minus 40°/65° to 260°/450°. Centigrade: Ranges from 0°/100° to 90°/185°.

**Recommended Applications:** For air conditioning units, oil circulating systems, farm milk tanks, commercial frozen food cabinets, walk-in coolers, refrigeration lines.

WRITE FOR BULLETIN 371

Manning, Maxwell & Moore, Inc.
East Main Street, Stratford, Connecticut

Send me complete technical information on

☐ 2½" Ashcroft Gauges
☐ 2½" American Thermometers

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Title_____

Company_____

Address_____

City/Zone_____ State_____

**MANNING, MAXWELL & MOORE, INC.**

*Gauge and Instrument Division, Stratford, Conn.*

*In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

←Circle 447 on Page 19

Circle 448 on Page 19

# NAME YOUR STAINLESS SHAPE!

The design and manufacture of quality stainless steel castings is a specialized job . . . *and Dodge specializes in it!*

There is practically no limit to the variety of shapes we can turn out to meet your simple or intricate specifications precisely . . . economically.

Perhaps one or more DS castings shown here will help spark an idea of how Dodge can be of assistance for *your* stainless steel casting needs. A blueprint or sketch with operational details will bring complete information, without obligation.

**DODGE STEEL COMPANY**

**6501 State Road**

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• *Phone: DEvonshire 2-2200*

DS DODGE PRODUCTS

THE MOST IMPORTANT ALLOY IN A STAINLESS STEEL CASTING IS QUALITY

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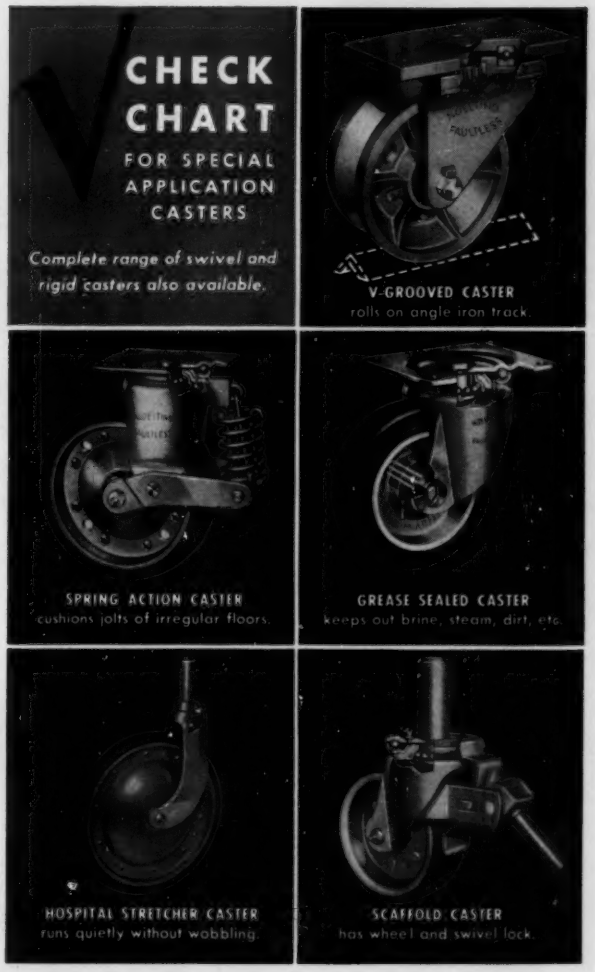
## ONE source . . . ONE responsibility

With over 10,000 caster types, sizes, and varieties in the Faultless line, *The Casters* you require to move your products efficiently, economically are available from this one source. Faultless makes all caster types, all caster sizes—light, medium, or heavy duty, plus special application casters. Each Faultless caster type or size, before it is marketed, goes through a complete series of tests in the extensive Faultless Testing Laboratory. Thus, you are assured that each caster meets, or exceeds, published specifications. Faultless Caster Corporation is proud of its 70 years of producing *Quality Casters* and standing behind them in every way.

Your Faultless Industrial Distributor, or nearby Faultless Sales Engineer can supply you with detailed information on the complete, quality-tested Faultless Caster line. Also, your Faultless Distributor stocks casters at his warehouse for immediate shipment.




NOELTING Faultless Casters

**Faultless Caster Corporation**
**EVANSVILLE 7, INDIANA**

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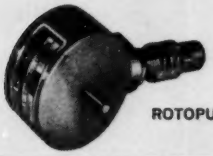


ROTOPULSER

*New product news from Louis Allis*

# NOW... Louis Allis offers DYNAPAR* Digital Control Systems!

## Louis Allis can supply accurate digital controls designed to industrial standards for a wide variety of continuous process lines

For any production process, Louis Allis can furnish not only motors, drives, and controls, but also digital monitoring equipment to provide visual readout and process control signals.

The answer is DYNAPAR* Digital Control — a highly accurate digital logic system that can count, measure, totalize, indicate, time, or control depending on the requirements of the application. Digital systems are ideally suited for high speed counting — accurate measurement of speed and draw — automatic cutting-to-length — automatic positioning — and many other applications.

Dynapar's digital devices utilize precise pulses, and eliminate the drift inaccuracy inherent in magnitude-measuring analog systems. There's no need for constant calibration or adjustment. Pulses are reliably provided by rugged ROTO-PULSERS, highly stable sensing and pulse generating devices — visual indication is obtained by easily-read luminous direct numerical readouts. Control functions are accomplished by a variety of special devices tailored to specific operations. All DYNAPAR equipment features the most modern solid-state transistorized circuitry to provide long-life operation without maintenance.

Investigate to see how Louis Allis-Dynapar equipment can increase production and cut waste by automating *your* process. Call your local Louis Allis District Office, or write to The Louis Allis Co., 459 E. Stewart St., Milwaukee 1, Wis.

*Dynapar Corporation is the electronic subsidiary of The Louis Allis Co.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

**LOUIS ALLIS**

Circle 451 on Page 19

# DEPENDABILITY of shifter fork improved by designing it to be FORGED

*Modern board forging hammer*

By designing the shifter fork of his transmission to be forged, a manufacturer of earthmovers eliminated costly equipment breakdowns in the field because of fork failure. Factor of safety was *in*creased even while weight and over-all costs were being *de*creased.

Parts scrapped because of voids uncovered after much high-cost machining are eliminated . . . forgings are *naturally* sound all the way through. Forgings start as *better* metal . . . are further *improved* by the compacting hammer-blows or high-pressure of the forging process.

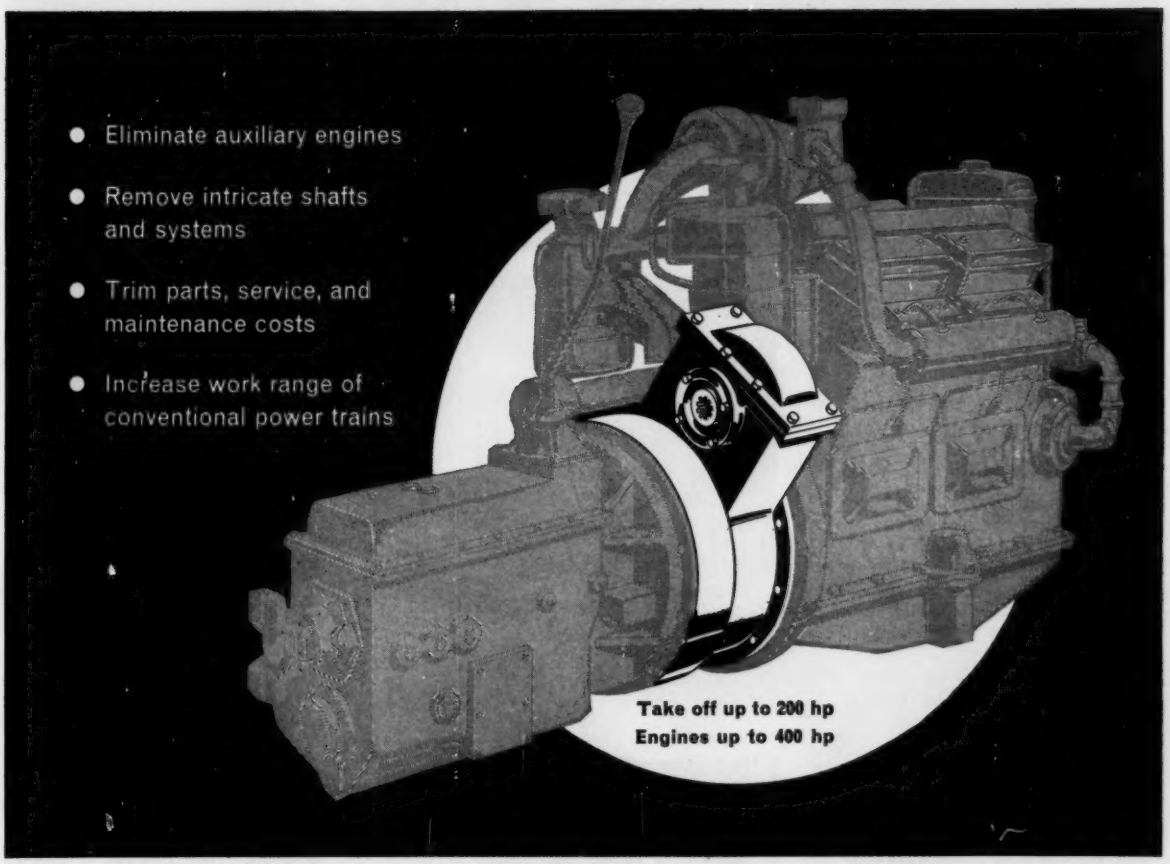
Design your parts to be forged . . . increase strength/weight ratio, reduce as-assembled cost, improve performance. Literature to help you design, specify, and procure forged parts is available on request.

*When it's a vital part, design it to be* FORGED

Drop Forging Association • Cleveland 13, Ohio

*Names of sponsoring companies on request to this magazine*

# NEW Four ways you can save with a Cotta heavy-duty flywheel power take-off




Now you can take 175 to 200 hp direct from engine flywheels, boost heavy equipment productivity, *and* eliminate direct and indirect costs of conventional PTO designs.

**You can increase versatility** of these and similar machines: heavy construction equipment, airport utility vehicles, fire trucks, generators, auxiliary hydraulic equipment, air compressors, and drills.

**Simple installation** fits a Cotta heavy-duty PTO between master clutch and flywheel of engines rated up to 400 hp. Even when clutch is disengaged, you can take off power at 1.24:1 ratio. Standard mounting — front and rear — with SAE No. 1 or No. 2 bell housings. Rotation at 30° increments positions unit for your specific job.

**Save maintenance time and costs.** Only 12¼" additional length on power train replaces auxiliary engines, shafts, joints, and couplings of conventional systems. One-piece cast housing endures heavy shock loads.

Cotta also customizes standard transmissions to individual applications . . . input torques from 150 to 2,500 ft-lb . . . single-speed, multispeed, and right-angle drives . . . variety of mountings.

For details, call Cotta (TWX-RK-7720; phone WO 4-5671) or mail coupon.


**COTTA**

**HEAVY-DUTY TRANSMISSIONS**

**Cotta Transmission Co., Rockford, Illinois**

Please send details on:

☐ New Cotta Flywheel Power Take-off

☐ Standard Cotta Transmissions customized to each application

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____



*Circle 453 on Page 19*

*Technical-ities*

By Fred E. Graves

### Fastening of rigid joints

Theoretically, there's no such thing as a rigid joint. There's always some elasticity of the fastened metals. For practical purposes, you can consider a joint rigid when the bearing areas of the metal-to-metal fastened members will not crush or yield before the full load-carrying capacity of screw or bolt is developed.

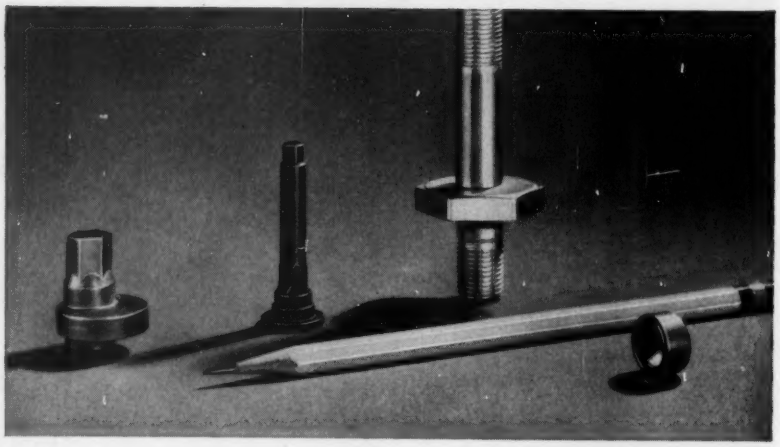
#### PRODUCT BENEFITS

Rigid joints afford a definite product advantage. They can take high strength hex screws or bolts tightened up to fastener yield strength or beyond. Under such tension, fasteners have demonstrated that they'll stay tight despite vibration. They are resistant to fatigue from the constant load reversals. High Strength Hex Screws cut costs and speed assembly too, since you can reduce *size* of the fasteners or their *number*, while actually improving joint strength.

#### INSTALLATION HINTS

When you're connecting steel members of fairly heavy section, you've no problem getting a rigid joint. Just clamp them to the full fastener capacity. Thin sections can be reinforced and similarly fastened. And in joining milder steels or softer metals, use of a plate washer will distribute bolt load, prevent crushing and give the desired effect of rigidity.

# When to plan on cold-formed special parts



COLD forming is basically a large volume, low cost method of obtaining component parts.

Above you see four specific *types* of parts that benefit from this production method:

#### ECCENTRIC SHAPES

When the piece is radically eccentric, and is further complicated by having several different diameters, cold forming may prove the only way to produce the piece at a reasonable cost. Machining it from a bar would be prohibitive in scrap loss and machining time.

#### MULTI-DIMENSIONAL DESIGNS

When pieces are complicated, cold formers can often shape item in two or three blows. Tolerances are close enough for practical uses, and no further finishing need be done except for some secondary machining or drilling if required by the design.

#### ONE-PIECE PARTS

When simple, small two- or three-piece assemblies can be replaced with unit parts, the production man saves assembly time as well as material costs; the designer gets a stronger part. For example: stud with integral hex, square, or round upset anywhere in-between. Note the extreme upset shown.

#### PARTS WITH HOLES

Nut formers produce parts by the thousands per hour like the one shown above. Holes are punched out, leaving smooth, clean, work-hardened and strengthened surfaces.

Bear in mind that unlike machining, cold forming cuts none of the metal's flow lines. So parts are tougher and more fatigue-resistant, as well as more economical.

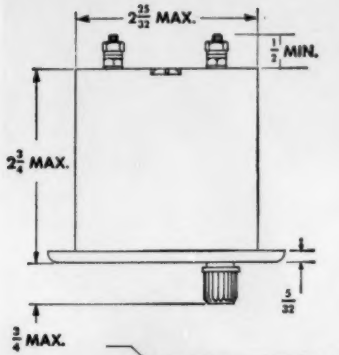
As a fastener manufacturer, RB&W makes an ideal and experienced source of supply for such items. The same facilities used for standard screws and nuts can also pound out the required specials. Refer your problem to Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

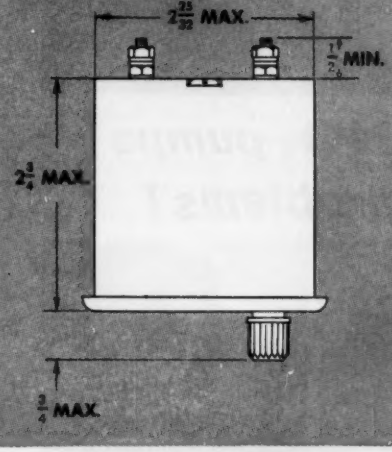
**Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Sales office and warehouse at: San Francisco, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas.**



Circle 454 on Page 19

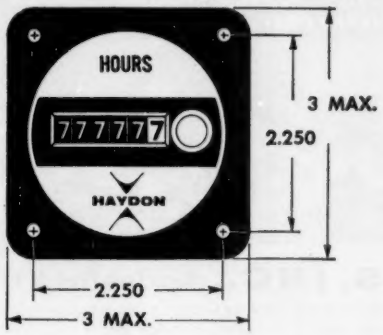
# New Series EN and ER Commercial ELAPSED TIME INDICATOR





Ideal for use on machine tools and other industrial or commercial machines and equipment where an accurate record of operating time is required—for efficient preventive maintenance procedures, for rental-basis operation, or for substantiation of manufacturers' guarantees. High-styled face registers hours and tenths and minutes and tenths up to 99,999.9 in big, easy-to-see figures on a direct-reading dial . . . and offers you highest quality and reliability, compactness and light weight at a lower price than comparable units. Available in resettable and non-resettable models with 3½" round bezel or 3" x 3" square bezel. Designed for operation at 120 or 240 vac, 50 or 60 cps. Low input: 5.0 watts at 60 cps, 3.4 watts at 50 cps. Write today for complete information and engineering data: Haydon Division of General Time Corporation, 3126 East Elm Street, Torrington, Conn.




TIMING MOTORS
TIME AND TORQUE CONTROLS

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DIVISION OF GENERAL TIME CORPORATION

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Circle 455 on Page 19

*special application*

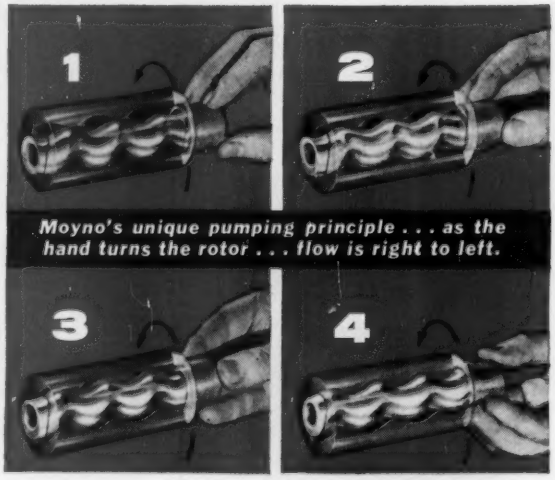
MOYNO® PUMPS

# *New special application* MOYNO® *pumps solve many product problems!*


Here is a completely new concept in small pumps. These Moynos successfully handle materials ranging from watery liquids and abrasive slurries to large particles in suspension. They use a single moving pumping element . . . have no pistons, valves, high-speed impellers or other quick-wearing parts. Moynos easily handle solids and abrasives that ruin piston pumps. They minimize sealing surface problems common to rotary pumps . . . don't cause foaming and aeration like centrifugal pumps do.

Moyno Special Application Pumps are available in two basic designs, each with or without direct-connected motor, in capacities up to 1200 gph and pressures to 300 psi. If your pumping requirements are so special that custom-designed Moynos are indicated, our engineers will examine your problem and recommend Moynos specifically suited to your needs.

Write today for copy of new Moyno bulletin 55-MD




*Moyno's unique pumping principle . . . as the hand turns the rotor . . . flow is right to left.*

**ROBBINS & MYERS, INC., Springfield, Ohio**

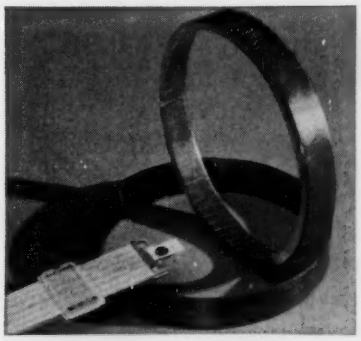
Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
*Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.*



Circle 456 on Page 19

# PRODUCT-DESIGN BRIEFS FROM DUREZ

- **High-impact phenolics for shock environments**
- **Fast forming with thermosetting resins**
- **Fire retardance plus in structural plastic**



### Better impact strength

The reverse clutch cone pictured here is molded of Durez 16771, a high-impact phenolic material made with fibrous glass. The cone does duty as a brake against which the steel ring gear of a planetary train is stopped while the transmission is under full power.

In this application, the part is buffeted by murderous static and dynamic friction, developed heat, and the 5000-lb. force of the actuating piston. It must also do battle with the chemical effect of transmission oil.

The test performance proved that the phenolic part does a better job than metal in all respects. You would therefore expect it to do equally well in other shock environments—and you'd be right. A few examples: stud-welding gun, rocket nozzle, compressor support, motor end-bell, washer sheave, missile nose cone.

*Durez 16771* abounds in unique advantages, the most valuable of which is its refusal to warp or shrink. You can mold parts to exact dimensions, without needing to allow for shrinkage.

If *you'd* like a closer look at the properties and design advantages of high-impact phenolics, we'd like to send you a reprint of an article written for *Product Engineering*.

### A resin that forgets

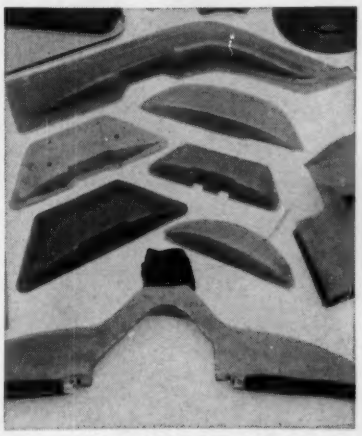
Forgetfulness is a virtue in this material.

It is a prepreg, commonly called "forming board," made from kraft fibers in which Durez phenolic resin has been dispersed as binder. The producer of the prepreg, whose name we'll be glad to send you on request, supplies it in thicknesses ranging from .060 to .150 inch, and in sheet sizes to 55 x 72 inches. A sheet can be stored two years at 70° F without losing its usefulness.

Squeezed at 300-500 psi in a hot press, the prepreg "sets" within 5 to 15 seconds to become a strong, rigid molded shape that will withstand moisture, heat and mild corrosives.

This is where forgetfulness comes in. There is no springback or "memory" effect in this forming board, because as it cures the resin changes its chemical nature to become a different substance, one of great durability.

As you might suspect, there are



many other uses for Durez thermosetting resins of interest to almost anyone developing new products. To get a better idea of how their interesting properties might help you, check the coupon for Bulletin D102, a 12-page idea book.

### Delight for designers

Structural paneling which incorporates Hetron® polyester resin in its manufacture is proving a boon to designers concerned with safety and strength . . . a delight to decorators seeking the attractions of color and translucence.

Hetron paneling is fire-retardant. It does not sustain combustion. It offers the added benefits of light weight, unbreakability, resistance to corrosion and to climatic extremes. It has high strength-to-weight ratio, excellent impact strength and finishing properties.

Other applications of Hetron range from auto fenders to portable hangars for jet aircraft. To enrich your knowledge of this versatile material, we'll gladly send you our Designer's Data File and the names of fabricators.

**For more information** on Durez materials mentioned above, check here:

- ☐ High-impact phenolic molding material (reprint of article)
- ☐ Thermosetting resins (12-page Bulletin D102)
- ☐ Hetron fire-retardant polyester resin (data file and fabricator list)

**Check, clip and mail** to us with your name, title, company address.
*(When requesting samples, please use business letterhead)*

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HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS


Circle 457 on Page 19

# SQUARE D NORpak

## —A SIMPLER, FASTER, STATIC CONTROL!

**NORpak** is a significant advance in the field of static switching. Like other static systems, **NORpak** performs the functions of machine tool relays, stepping relays, latching relays and timers —all without contacts or motion of any kind.

Like other static systems, **NORpak** is ideal for applications where speed is important—where reliability and long life are essential—where conditions make conventional magnetic devices impractical.

**But unlike other static switching systems, NORpak offers these important advantages**

### EASIEST TO APPLY

The transistor NOR unit is the basis of **NORpak.** All logic functions—AND, OR, NOT, MEMORY—can be accomplished with combinations of this single NOR unit.

**NORpak** is *not* complicated—it's easy to apply to conventional circuits. Units are color-coded for quick identification. Simple DC circuit eliminates worry about phase relationships.

### EXTRA DEPENDABILITY

NOR units have been time-tested in computer use for years. They are not subject to wear, will give top performance indefinitely, and provide unfailing circuit fidelity.

### SIMPLE TO USE

Optional monitor lights give visual evidence of proper performance. Simple dynamic sequence tester checks individual NOR units in operation.

### UNMATCHED SPEED

**NORpak** provides switching at rates up to 25,000 per second—faster than any other industrial static system.

### EXPERT APPLICATION HELP

Field specialists, factory-trained in all aspects of **NORpak** can give you on-the-spot answers to any application questions.

### SMALLEST COMMERCIAL PACKAGES

**NORpak** is available in the form of individual components, or in completely engineered systems. Components are offered in 6 and 20 paks, require only 1/4th the equivalent relay panel space, and weigh less than components of other static systems.

**NORpak** is available as individual components for application to specific control functions, or as completely engineered systems ranging from the smallest to the largest panels

*Write for the complete story on* **NORpak** *—its theory, application and operation... Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin*

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*wherever electricity is distributed and controlled*

# How Nickel gets music out of solid rock

Deep in the Caverns of Luray in Virginia is one of the world's musical marvels—the famed "Stalacpipe" organ—a unique instrument that gets rare tonal beauty from age-old stalactites.

To get music out of solid rock, the stalactites have threaded metal rods bolted through them—close to small, wire-wound magnets. When an electronically-controlled hammer strikes a stalactite, the combination of rod and magnet becomes a tone generator whose impulses pass out through an amplifier.

**Imagine the dampness of the Caverns** . . . the rust-producing environment . . . and what could soon happen to these musical rods bolted through the rock. Here is where a metal has to really prove itself.

**Nickel means trouble-free performance.** To prevent excessive rust and resulting expansion that could easily crack or snap off the stalactites, a special electrical steel—a steel with Nickel in it—was chosen. This high nickel alloy steel—47-50% Nickel—stands up to the eternal dampness of this underground concert hall . . . and provides the exact combination of magnetic properties needed for low power requirements and full high fidelity.

**Don't overlook Nickel** even if you're not thinking of building an underground organ anytime soon. Alone or with other elements Nickel improves hundreds of alloys . . . makes possible almost any combination of properties for fabricating or service demands.

**Whatever your metal problem**—high or low temperatures, corrosion, stress, or an unusual combination of factors—consider the advantages of Nickel. For more information, just write us.

**THE INTERNATIONAL NICKEL COMPANY, INC.**
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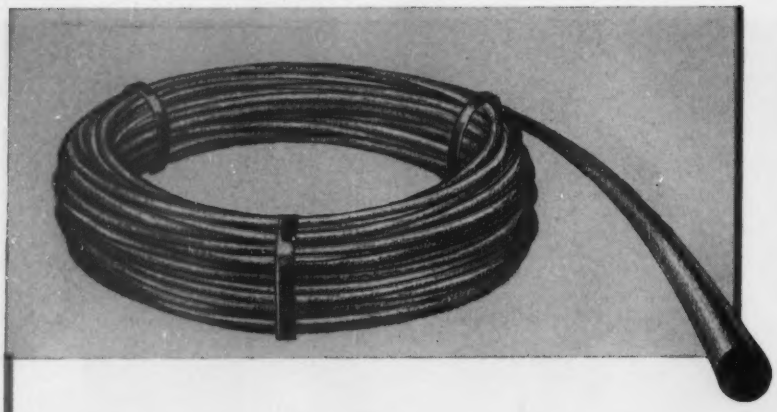
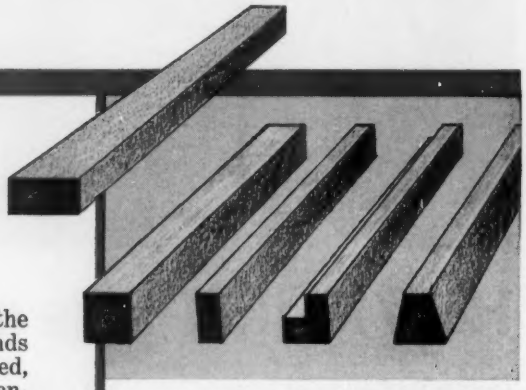
**Big tone from little Nickel alloy rods.** Pen shows the size of Allegheny Ludlum Steel Corporation's AL-4750 nickel alloy special steel rods bolted through ancient stalactites. The rods vibrate with the rock after being struck by rubber-tipped hammers.

**INCO NICKEL**
NICKEL MAKES ALLOYS PERFORM BETTER LONGER



## For Your Special Requirements Use

# EATON-RELIANCE COLD FINISHED STEELS

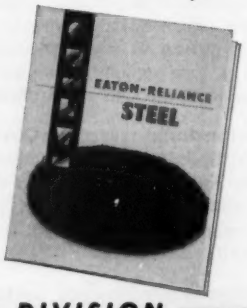


Eaton-Reliance can furnish shapes in the range of .020" x .020" to ½" x $\frac{9}{16}$"—rounds up through $1\frac{1}{16}$" (coils or bars)—cold rolled, cold drawn special shapes—keystone—centerless ground, finished to your specifications. Produced by the most modern machinery under the most exacting quality control procedures, you can be assured Eaton-Reliance special steels will meet your requirements.

All steel finishing is done in our own mill by experienced craftsmen who draw and roll steel for ball and roller bearings —rings—springs—keys—pins and cold heading. Countless sections are available including round, square, flat, rectangular, step section, keystone and hex.

Eaton-Reliance also cold finishes several non-ferrous metals in addition to carbon, stainless and alloy steels.

*Write for our 8-page catalog containing information about Eaton-Reliance cold finished steels and non-ferrous metals. No obligation.*

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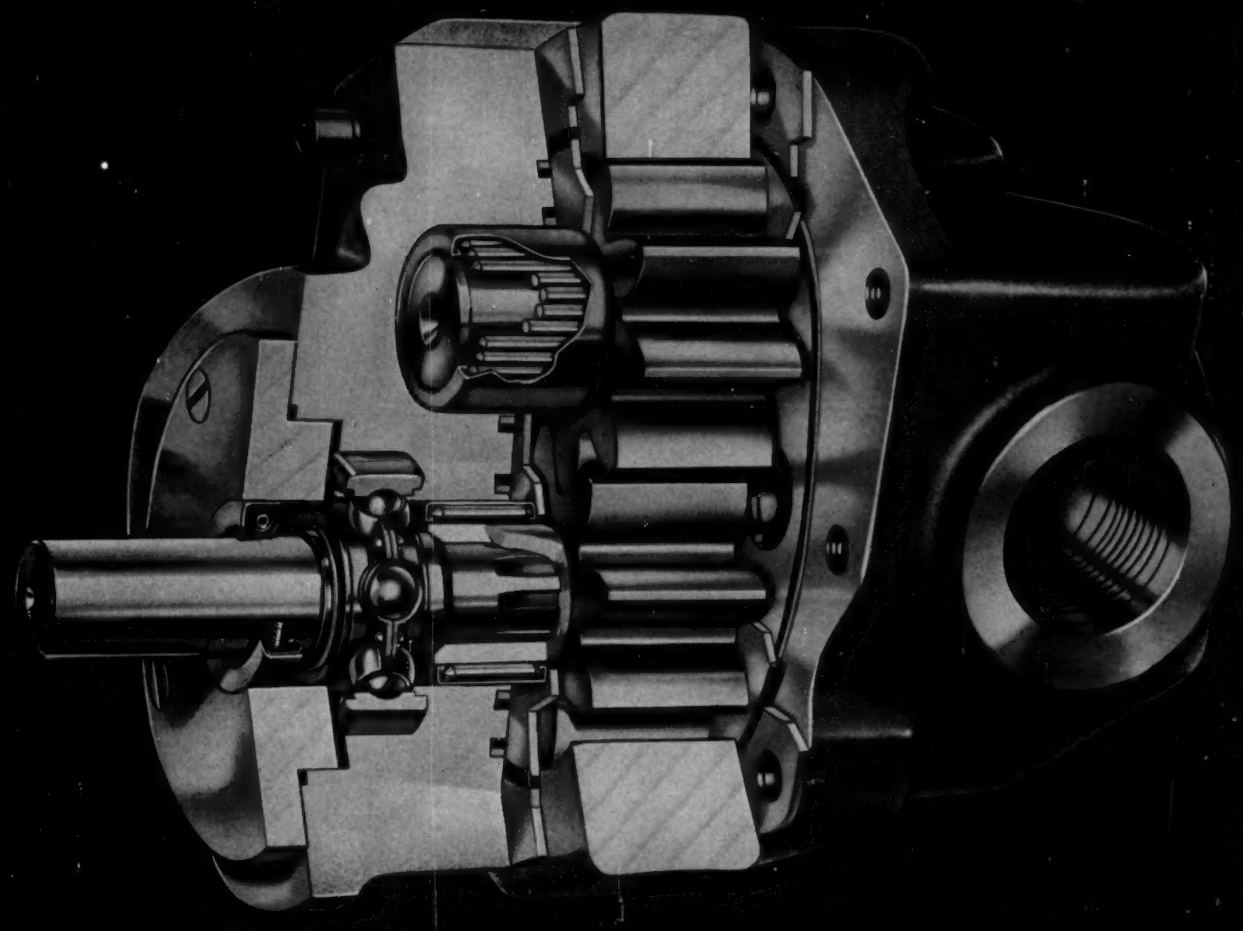
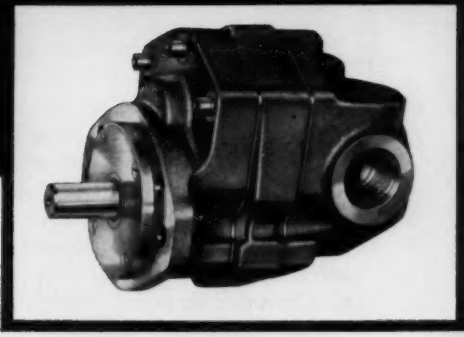


# POWER *for the biggest mobile rigs, toughest jobs!*



## WEBSTER "JD" SERIES HYDRAULIC PUMP

Match your big equipment to the most rugged duty with this newest Webster and you come up with some interesting answers in hydraulic performance. Fluid power up to 2000 psi! Requires less input horsepower! Saves fuel!

This sectioned view and the specifications at right tell the story. The "JD" Series' anti-friction bearings save power, pressure balanced wear plates assure high volumetric efficiency — other equally important features mean extra work output, trouble-free operation!

Webster Electric "JD" Series Pump is a trim, *very compact* unit designed to fit in tight locations. Ideal for agricultural, construction, industrial, utility equipment — machine tools as well. It's available in 5 sizes from 5 to 17 gpm — attaches easily with a choice of mountings. Ask your Webster Electric representative for all the facts on this powerful new pump — or write direct for engineering detailed sheet HY1-2.

**OIL HYDRAULICS DIVISION**

**WEBSTER ELECTRIC**

**RACINE · WIS**

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### SPECIFICATIONS

**Capacity:** 5 sizes, 5 to 17 gpm.

**Operating Pressure:** Up to 2000 psi.

**Operating Speed:** Up to 2400 rpm.

**Wear Plates:** Pressure balanced — prevent clearance changes from heat.

**Bearings:** 4 anti-friction needle bearings — save power or fuel. Ball bearings on drive shaft to absorb end thrust.

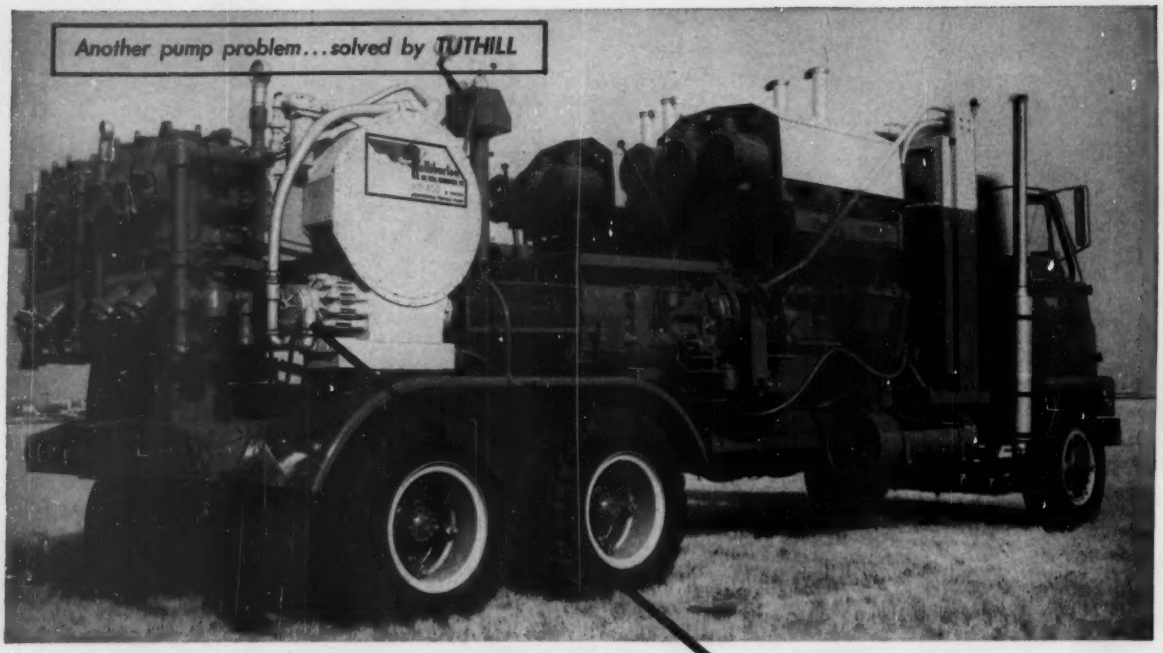
**Gears:** Smooth-running, spur cut. One piece gear and bearing journal units assure minimum deflection and proper alignment.

**Drive:** Free-floating internal spline — eliminates key failures.

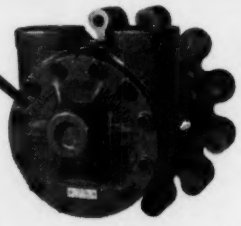
**Seal:** Double lip on drive shaft — added protection from seal failure and dirt.

**Porting:** End, side, or bottom.

**Mounting:** SAE Type A, 2-bolt mounting flange standard. Foot mounting optional.




# POSITIVE LUBRICATION of Halliburton "fracturing" units with TUTHILL PUMPS



The HT-400 truck mounted pumping unit is a proud manifestation of Halliburton's 35 years of leadership in oil field service operations. These units were especially developed for "fracturing" . . . the breaking apart and propping open of oil formations by hydraulic or fluid pressure . . . in which oil mixed with selected grades of sand is pumped into oil wells at extremely high pressures. A pair of HT-400 units, mounted side by side, can deliver over 1,000 hydraulic horsepower . . . move over 42 barrels of oil per minute . . . or, with modifications, reach pressures of 20,000 psi.

For positive lubrication and cooling Halliburton selected Tuthill model 6C pumps as an important component of the rugged HT-400. Special modifications of the shaft and mounting bracket by Tuthill's application engineers permit the 6C to be assembled into the Halliburton unit with the greatest possible ease.

## Over 800 standard models

This model 6C is one of over 800 models in Tuthill's complete selection. These include reversing pumps, special pump motor-combinations, and stripped units for OEM use. They may be furnished with a wide variety of modifications including built-in relief valves, automatic reversing feature, special porting arrangements, special seals or shaft extensions, and many more.

Probably a Tuthill standard model can provide an economical, dependable answer to your pumping problem. But if your application requires it, Tuthill's engineers will develop modifications or special features to provide the best possible solution to your pumping problem.

Catalog 100 describes the complete Tuthill line. Write for your copy. Or forward information on your application, so we can indicate how our engineers may be able to provide savings.

*Tuthill manufactures a complete line of positive displacement rotary pumps with capacities from ½ to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.*

PUMPS FOR YOUR PURPOSE

**TUTHILL PUMP COMPANY**

953 East 95th Street, Chicago 19, Illinois



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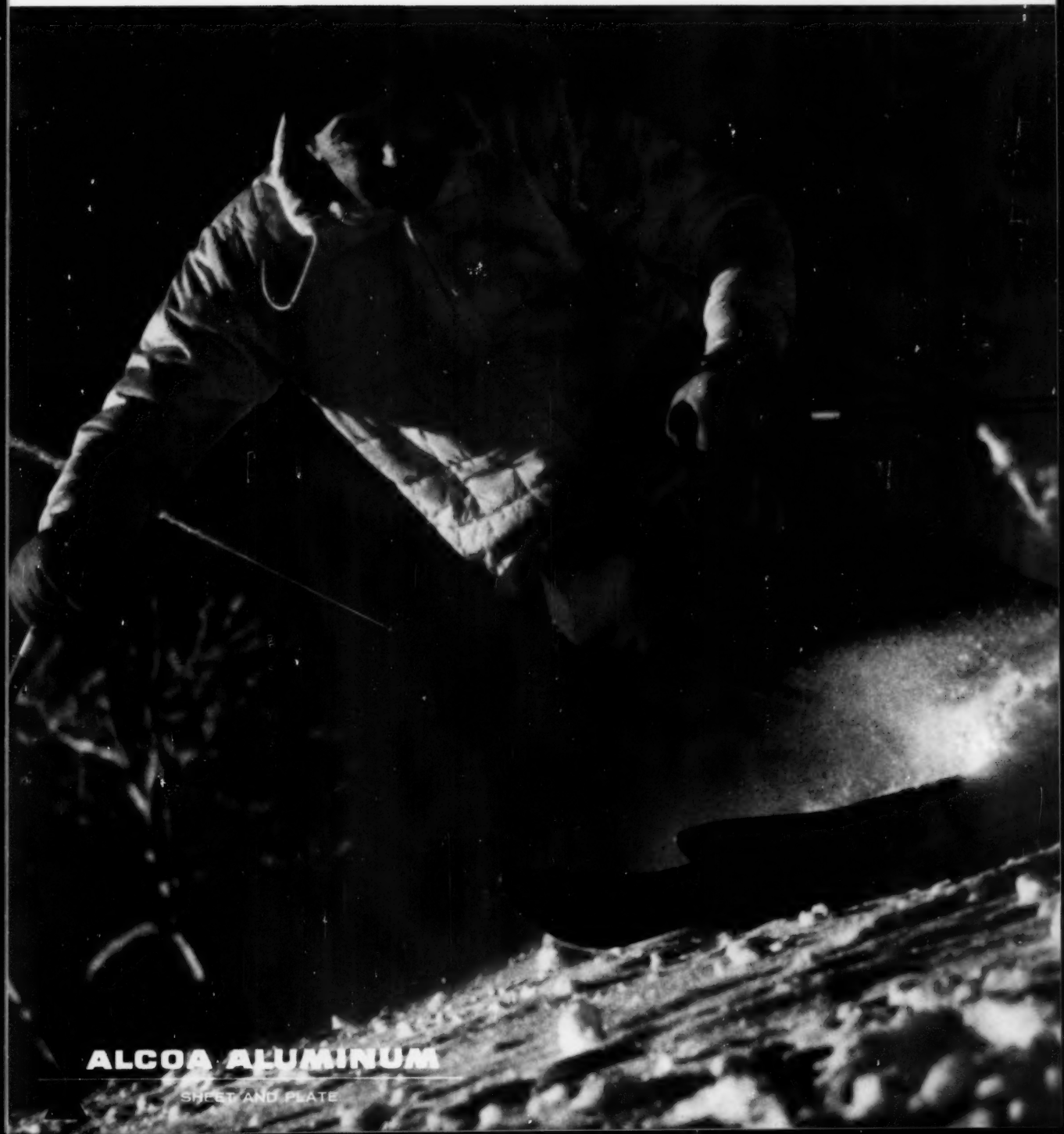
*When a six-pound aluminum ski takes a 10-G load . . .*

Bud Phillips on Head Skis at Mad River Glen



*When a 6-pound ski takes a 10-G load . . .* # *that's Alcoa Total Ability at work!*

Talk about strength-weight problems! When a husky skier whistles into a tight turn, he puts a surge load of 10-G's or more on a single leg. To stand loads like this, a ski must be strong enough at the footpad to support a ton. At the same time, the ski can't weigh more than five or six pounds.

Head Ski Company was the first ski manufacturer to exploit the gifts of the strongest aluminum alloy made—an Alcoa development. Springy, lively aluminum alloy and Head's mastery of design make possible a sandwich construction which places the elastic, strength-carrying material at the surface, as far as possible from the neutral axis. Lightweight core material in between carries shear loads. Head skis won't twist in action like a wood ski, won't warp, dry out, deteriorate, lose camber or life or resilience or strength.

No one knows more about aluminum sheet and plate—nor makes more alloys, tempers, finishes, widths, thicknesses (even *tapered*)—than Alcoa. *Alcoa Total Ability* includes working with your people from the design stage to the finished product, with significant contributions all along the way. Let us prove it. Simply contact your nearest Alcoa sales office, or write Aluminum Company of America, 856-C, Alcoa Building, Pittsburgh 19, Pa.

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ALCOA TOTAL ABILITY GIVES YOU SHEET AND PLATE THAT'S UNSURPASSED FOR . . .


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STRENGTH-WEIGHT RATIO

NONSPARKING PROPERTIES

MACHINE DESIGN
March 30, 1961

# For Players Only

AN ENGINEERING manager has to be, or ought to be, an engineer. Yet, perversely enough, attitudes and skills required of an effective engineer often aren't convertible to managerial ability.

The good engineer who becomes a poor manager is no stranger. The premise of such an appointment is like the fallacy that expertness as a player qualifies one to manage the team. Knowing the game is essential, but it doesn't guarantee success.

The desire to advance via the supervisory or managerial route isn't enough either. And fulfillment of the desire could be disappointing. As Ben Franklin punned, "If a man could half his wishes he would double his troubles."

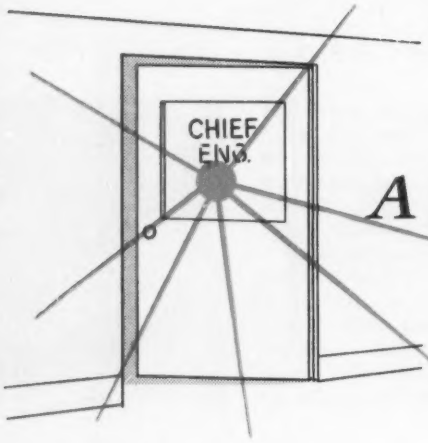
Players do become managers—some better than others. The odds are that the man who gets the nod has been doing more than just dreaming about it. He has examined routes of advancement, analyzed expected responsibilities, studied supervisory techniques—in short, prepared himself.

Once appointed, he knows his continuing success depends upon gaining more insight and skill—now as a manager, not as a player. Bob Murdick outlines overleaf some of the new and different kinds of things a man has to think about if he is to change from player to manager.

The next boss of your group is likely to be one of the four or five fellows around you—or you. Who will it be?

Ben Hummel

EXECUTIVE EDITOR




# *A guide to making a smooth transition*

How does an engineer get into management —and once he's there, how does he prove himself?

Any engineer who aspires to management should make sure he's following the right route to get there. Obviously, he should know something about a company's organization setup. In addition to this, however, he should choose his route to the top carefully. And once he reaches his goal, he should be able to take command quickly and effectively.

This article explains the six major routes an engineer may follow in moving into management. It also suggests an approach to the manager's job. Another article, to be published in the next issue of MACHINE DESIGN, will discuss the planning work of the engineering manager.

# FROM ENGINEER TO MANAGER

**ROBERT G. MURDICK**
Dept. of Management Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

RECENT studies have shown that the technically competent engineer is receiving greater recognition and remuneration than ever before. Nevertheless, the greatest financial rewards are still reserved for those who move up into management. But the engineer who considers making such a change in his career should recognize that his choice may be irreversible.

From a social viewpoint, of course, no creative worker should be diverted from his work as long as he can continue in it. Many engineers, however, are better equipped to do executive rather than creative work.

The main problem confronting the management-minded junior engineer is how to move up from the ranks. For senior engineers or lower-level managers who have been offered promotion to engineering management, the important question is, "What specific, practical, systematic approach can I make to my new job to show that I can handle it?"

## Basic Routes from Engineer to Manager

The first major step on the way to engineering management is to graduate from "engineer" to "manager." Once an engineer has moved up onto the management ladder—even if he is only on the lowest rung—he is in an entirely different class. Usually, a manager who is doing his job correctly does little or no engineering work himself, but accomplishes his goals through the efforts of his people.

Usually, there are six primary routes open to the future manager. He can:

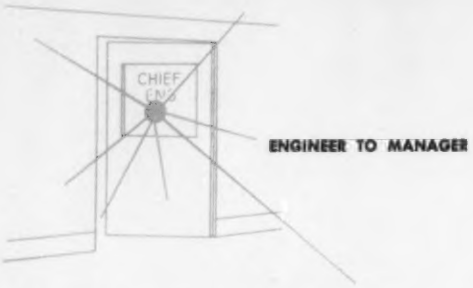
1. Show outstanding technical competence and some organizational ability.
2. Be aggressive in evaluating, summarizing, and presenting work segments larger than his own.
3. Move up through a sponsor-protege relationship.
4. Move from one company to another at relatively frequent intervals.
5. Become a consulting engineer, then switch to manager.
6. Show dependable engineering work plus outside leadership in important community and professional activities.

**Technical Competence:** There is very little an individual can do about this—either he is gifted or he isn't. If an engineer has superior ability and is assigned new men to help him on larger projects, he is on his way.

**Evaluation, Summarization, and Presentation:** If the engineer recognizes his limitations in creative work or his lack of technical superiority, he is not necessarily barred from management. If he is adept at seeing the over-all picture . . . if he is able to organize and communicate the problems and accomplishments of the work group and is aggressive in expressing group opinions . . . if he proposes plans for the group, takes on such work as scheduling, cost estimating, and small administrative tasks at every opportunity . . . he may easily overcome any disadvantages.

**Sponsor-Protege Relationship:** Most organizations are complex networks of sponsor-protege relationships. Each manager wants men whom he likes and can depend upon. As he moves up, he seeks promotion of these men to work for him.

**Job-Changing:** In the early stages of his career,




an engineer may prefer to build up his technical specialty with one company over a period of two or three years and then go into the market for a better job. In most companies, progress is slow and not always steady. On the other hand, a company which is expanding and requires experienced engineers must be willing to offer added inducements.

The engineer who is mobile has a considerable advantage over his stable colleagues. If a man changes jobs only three or four times in his first ten years, he need not worry about being classified as a "floater" by even the more conservative companies. But the engineer should not accept promises of opportunity as a substitute for a good salary and a responsible position.

**Moving from Consultant to Manager:** The management-conscious engineer may decide to attain his ends by first becoming a consulting engineer. In this case he should select as his specialty one that is basic to the company's main engineering work. For example, in a company devoted to pressure-vessel design and manufacture, the engineer might build his reputation in stress analysis and materials application. This would be more useful than becoming a specialist in, say, fasteners or finishes. After the engineer has risen to the level of consulting engineer, he is then in a position to broaden both his knowledge and his relationships and to be on the lookout for first-line managerial openings.

**Leadership Outside the Company:** By long, dependable service with the company combined with active leadership in community activities such as

## NOW YOU'RE A MANAGER . . .

### Set Up the Organization

- Get a charter which spells out your duties and relationships with other individuals and departments.
- Be sure that your department is well organized, with all subordinate jobs well defined.
- Make sure that your immediate subordinates, and also the next lower echelon, understand their responsibilities.
- If there are any cliques, former managers, etc., make it plain that all major decisions are to be yours.
- In hiring subordinates, place a premium on a combination of experience and potential, rather than on experience alone.
- Be sure the people in lower-echelon management spots are capable of managing properly. Personality and psychological tests are often misleading.

### Expect a Good Job

- If the people you hire are not doing a satisfactory job, tell them. Outline the standards you expect, and let them know that if they fail to deliver, you have no choice but to replace them.
- Don't supervise your lower-level managers too closely, but meet with them individually for a short time each week.
- Make it plain that you expect a good job. In most cases your men will live up to your expectations.

### Learn to Handle Problems

- Keep your own superior notified of what problems arise, but don't call him unless necessary. If you think a problem warrants his attention, leave a message for him. This gives him the option of getting in touch with you or not, as he sees fit.
- When an urgent problem comes up, move in fast and follow the details closely. Leave no doubt that you have taken charge. If necessary, work yourself and your men around the clock.
- Don't be afraid to ask questions when problems come up.
- Learn to evaluate accurately any information that comes your way. A good manager doesn't have to be a good engineer, but he should be able to sift evidence and come up with a decision.

### Get the Job Done Right

- When a new job comes up, analyze it and start making your plans. See that current jobs are carried on by delegation, and spot check to see that things keep running smoothly.
- Keep in touch with major reports on manufacturing, finance, marketing, etc., which may have an effect on engineering. Try to find areas where engineering's contribution may be extended.
- Anticipate problems. Avoid the possibility of having to push the panic button.
- See that jobs are done on schedule. Be sure that all specifications are met and that nothing is shipped out that doesn't meet engineering specs.

Chamber of Commerce work, Community Chest drives, municipal and educational study groups, etc., the engineer can develop management and personal relationship skills. While this method provides perhaps the best means of all-around development, it is a lengthy and time-consuming process.

## ▶ Moving into Management

The step from lower-level management in the engineering organization to engineering manager is a big one. Certain duties, responsibilities, and objectives concern only the top man. But any engineer who aspires to top-level management should be aware of the requirements, and should keep them in mind when performing his own duties. Many of the points which seem to be of concern only to the engineering manager can broaden the outlook of any member of the engineering organization.

The manager of engineering stands alone, with no superior in his field to lean on. It is essential that he take control smoothly and surely.

When a new top-level manager takes over, he often finds that:

1. The generalities of management textbooks on how to "plan, organize, initiate, control, and measure" aren't specific enough for the time and knowledge he has available.
2. His previous experience is too narrow and his management techniques are no longer strong enough.
3. Daily operations and long-range plans begin to press in on him with increasing intensity.
4. He is unable to come up with either a good place to start or a systematic approach.

The new manager may have to face either of two extreme situations—or any variation of them. He may have been granted freedom to establish a new engineering organization, or he may be expected to take over a rigid, old-line established organization where adaptation to changing conditions is encouraged.

**Establishing a New Engineering Group:** A simple checklist provides the framework for major steps—and their order of importance—in establishing a completely new engineering organization.

1. Define broad objectives.
2. Select the desired engineering activities.
3. Outline the engineering organization.
4. Obtain the charter.
5. Establish program objectives.
6. Complete the organization development.

*Defining Broad Objectives*: The manager of engineering may decide he wishes to:

1. Assist the general manager by providing long and intermediate-range plans for technical and product leadership.
2. Provide research, development, and design of new products.
3. Provide technical development of existing product lines.
4. Provide test facilities.
5. Maintain quality control, product reliability, and value analysis functions.
6. Administer technical service groups such as a technical-information-search center, centralized computer facilities, drafting and reproduction services, special laboratories, etc.
7. Maintain sales and service engineering activities.
8. Conduct manufacturing engineering activities.
9. Conduct plant engineering activities.

While it is unlikely that a newly appointed manager of engineering would have either the desire or opportunity to establish all these broad objectives, a partial combination of the above objectives may be appropriate in some organizations.

*Setting Up the Engineering-Organization Structure*: The new manager of engineering should consider his own background and knowledge to make sure that in establishing his organization he does not bite off more than he can chew. In addition, he should consider the wishes of the managers of marketing and manufacturing.

The problem can be considered to be one of subdividing the over-all work area, where engineering may extend into marketing on the one side, and into manufacturing on the other. Depending upon the freedom which the new engineering manager has, the size and nature of the company, and budget limitations, the manager may select a set of functions from those given in Table 1.

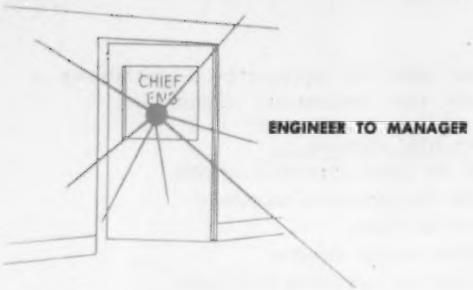
In a relatively small company which cannot afford a large R & D group, a few scientists or highly trained engineers may carry out special investigations, keep in touch with pertinent scientific advances throughout the world, and serve as consultants to the other engineers.

Advanced engineering development, which performs work essentially of a conceptual or systems nature, may be included in the engineering organization. Otherwise, such development work must be subcontracted, or the long-range and new-product work must be neglected. This is a somewhat dangerous alternative.

In larger companies, technical supporting services are helpful in maintaining a high quality of engineering and engineering leadership. These consist

**Table 1—Engineering Subfunctions**

1. Research and Development
2. Advanced Engineering Development
3. Engineering Design
4. Engineering Development Testing
5. Engineering Proof Testing
6. Engineering Technical Supporting Services
7. Engineering Administration
8. Package and Style Design
9. Application Engineering
10. Field Engineering
11. Manufacturing and Process Engineering




of specialized groups such as metallurgists, chemists, and instrument experts, and offer the services of laboratories containing specialized equipment. Even in smaller companies some such services are usually made available.

With regard to packaging and style design, application engineering, and field engineering, the engineering manager must be guided by the nature of the business and his relationship with the marketing manager. If new products or new product lines must be worked out, the engineering manager must expect to work closely with the marketing manager. A manager's plans involving manufacturing and process engineering will of course bring him into close contact with the manager of manufacturing.

*Obtaining a Charter in Writing*: Many new managers, taking over positions in an aura of good will, fail to have their duties and relationships spelled out. They feel that they are on a good team, the work is too fluid, and everyone already knows his job. Many learn to their sorrow that times change, working pressures strain good will, and relationships shift with respect to power and pressure.

The manager of engineering should obtain a charter in writing as soon as he is certain what his objectives are, what responsibility and authority he requires to achieve those objectives, and what his relationships should be with company management, his fellow managers, and the staff managers.

The charter may be in the form of a letter, a position description, or a functional organization description. It should spell out the principal responsibilities of the engineering manager and specify, in particular, those responsibilities which may conflict with sales, manufacturing, or staff organizations. A charter need not be a legal document delineating every possible detail of the work. The charter simply serves as the framework within which good working relationships may be maintained by men of integrity. It is a reminder of the original conditions on which the manager accepted his position.

*Establishing Program Objectives*: Once the engineering work has been mapped out in general terms and the tentative organization plans made, key engineers and lower-level managers should be hired. With the assistance of these key men, the manager can then continue with the planning task in more detail to:

1. Establish program objectives and schedules.
2. Further subdivide the work into manageable packages, define it in detail, and assign responsibilities and relationships.
3. Develop the plans for the engineering program so that they are integrated with those of other functions.

At this time, significant product qualities should be carefully defined, Table 2.

*Completing the Organization Development*: Along with the refinement of program and product objectives goes the completion of the organization work. This includes hiring engineers, technicians, draftsmen, and supporting personnel.

At this point, all objectives, goals and plans have been identified, all work has been selected and accounted for, each work element has been defined and an organization chart has been prepared. Work has been grouped into full-time positions, and positions have been grouped into functional organizational components.

The next steps in staffing the engineering organization properly are to write position descriptions, establish appropriate position titles, provide for performance measurement and evaluation, and evaluate the positions in accordance with a uniform salary administration plan. Plans for development of new engineers should also be made at this time.

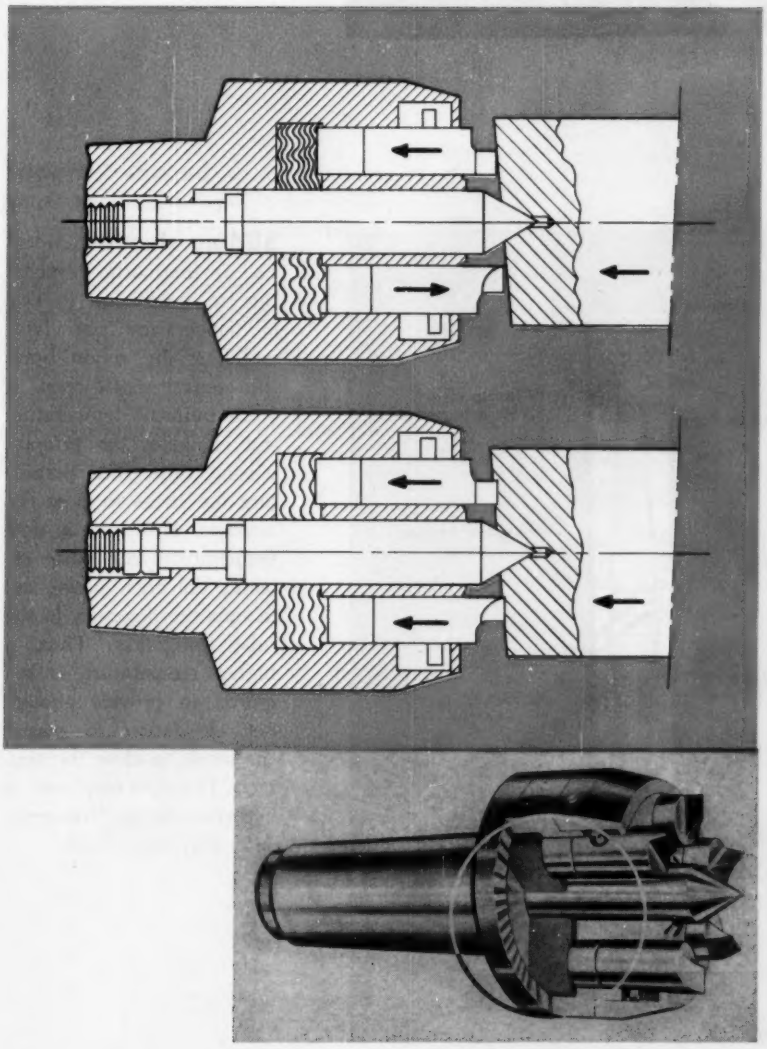
**Table 2—Product Qualities**
To Be Determined When Setting up the Engineering Organization

| Performance | Features |
|---|---|
| Technical characteristics | Physical characteristics |
| Operating cost | Special functions |
| Reliability | Ease of installation and servicing |
| Life | Flexibility |
| Safety | Accessories |
| Uniformity | Interchangeability |
| | Safety |
| | Packaging |
| | Styling |
| | Compatibility |

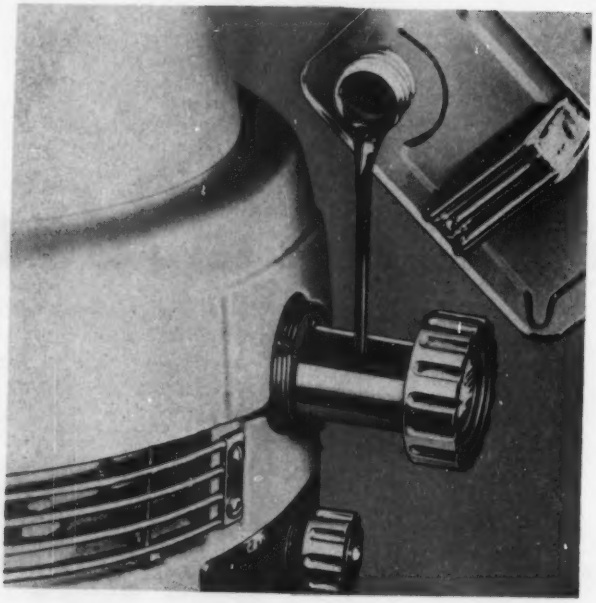
**Taking Over a Going Organization:** Taking over an established organization may represent a tremendous opportunity or a grand frustration for the new manager. If the organization is one of low morale, inefficient methods, and poor working relationships, it may offer a challenge which the new manager can meet. On the other hand, if the engineering organization consists of old-time long-service engineers who are set in their ways, divided into cliques, and resentful of a new manager, major surgery may be required which only the general manager can perform.

In either case, the new engineering manager should go through much of the thinking and planning process described in the first part of this article. It should serve as his blueprint for the future. But he should be careful about airing his plans at once, since changes will probably be brought about very gradually in such a rigid environment.

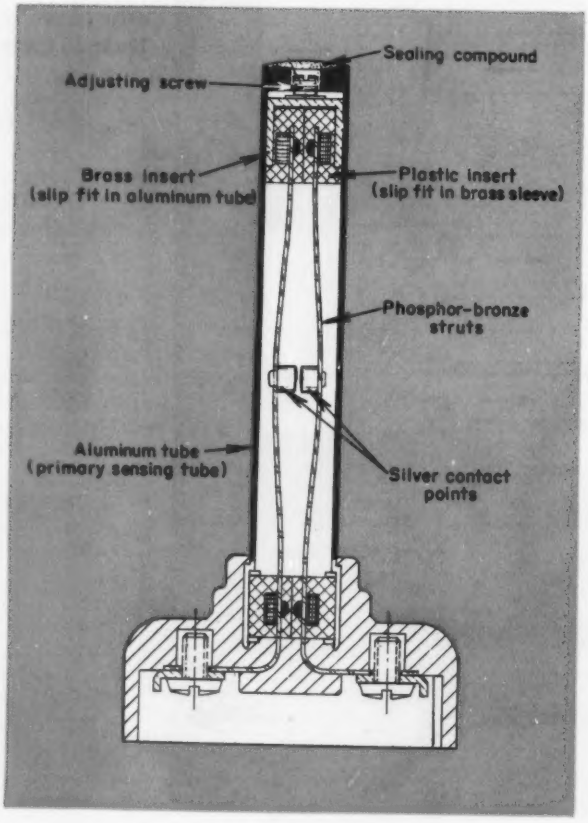
# scanning the field for *ideas*



**Plastic hydraulic 'fluid'** deforms to transmit force in a driving center. Pressure created by the first-contacting drive pin is transmitted by the deformable plastic to the remaining drive pins. Principle employed in a machine tool drive center by Powergrip Inc., Rockfall, Conn.

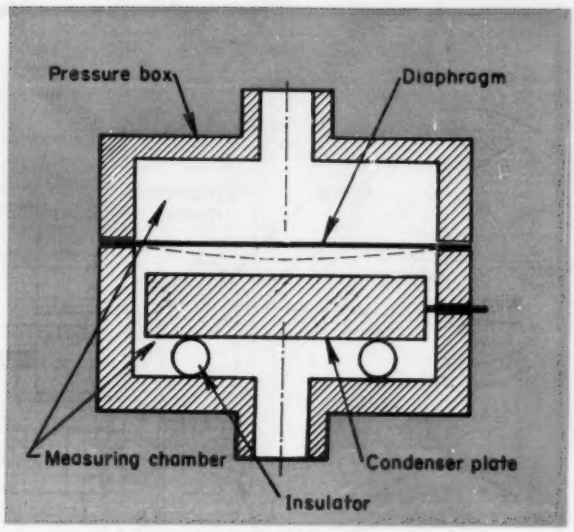


**Oil drawer** permits easy access for adding lubricant. In the normal position, the transparent end cap permits a visual check of the oil level. Principle employed in an electric motor by U. S. Electrical Motors Inc., Los Angeles, Calif.

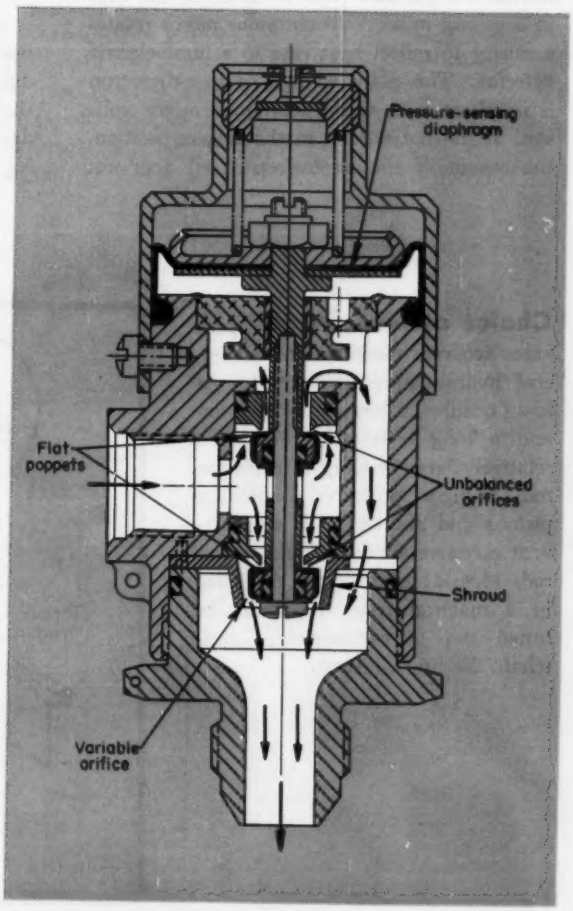



**Sliding sleeve** compensates thermostat response rate in proportion to rate of temperature rise. Normally, spring action holds the contact struts open. A quick ambient temperature rise elongates the primary sensing tube, thus permitting the struts to close the contacts. However, a slow temperature rise also expands the brass sleeve, but in opposite direction to the tube elongation. Thus, a higher temperature is required to provide enough net elongation to permit the struts to close the contacts. Principle employed in a thermostat by Tomorrow Inc., Hayward, Calif.

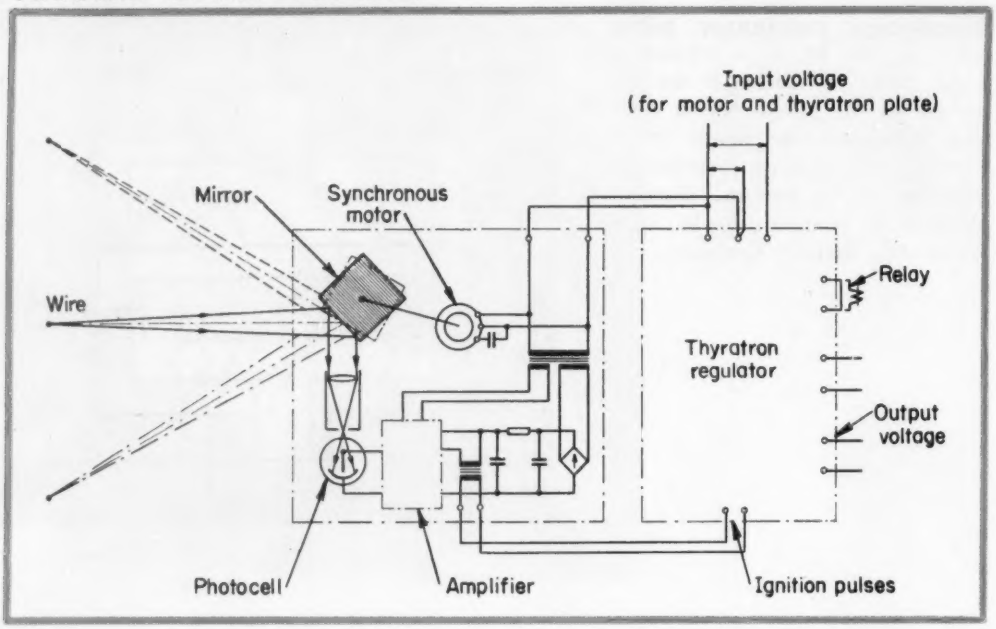
**Diaphragm condenser plate** serves as one leg of a capacitance bridge circuit. Deflection of the diaphragm by the pressure being measured unbalances the bridge circuit. External null-balancing provides an indication of the pressure. Principle employed in pressure gage by Atlas-Werke AG, Bremen, Germany.




**Tapered shroud** around lower poppet provides a variable-size orifice to permit use of unbalanced orifice areas in a double-poppet pressure regulator. Without shroud, the unbalanced orifice areas, necessary for positive shutoff, would cause the output pressure to drop excessively at high flow rates. Principle employed in pressure regulator developed by Weatherhead Co., Cleveland, Ohio.

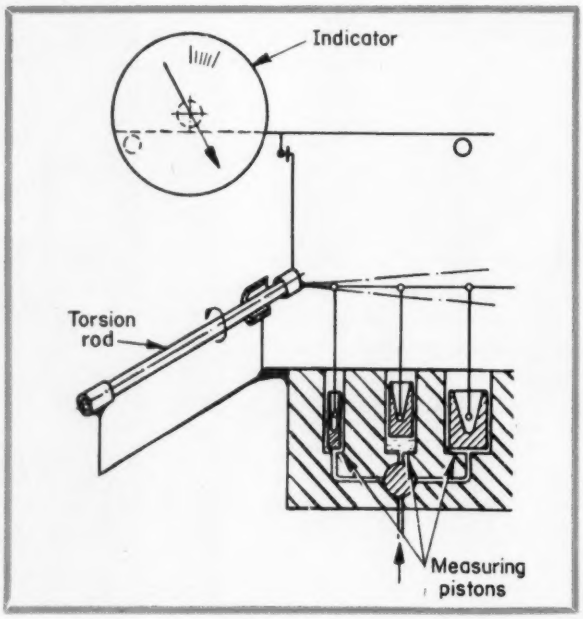


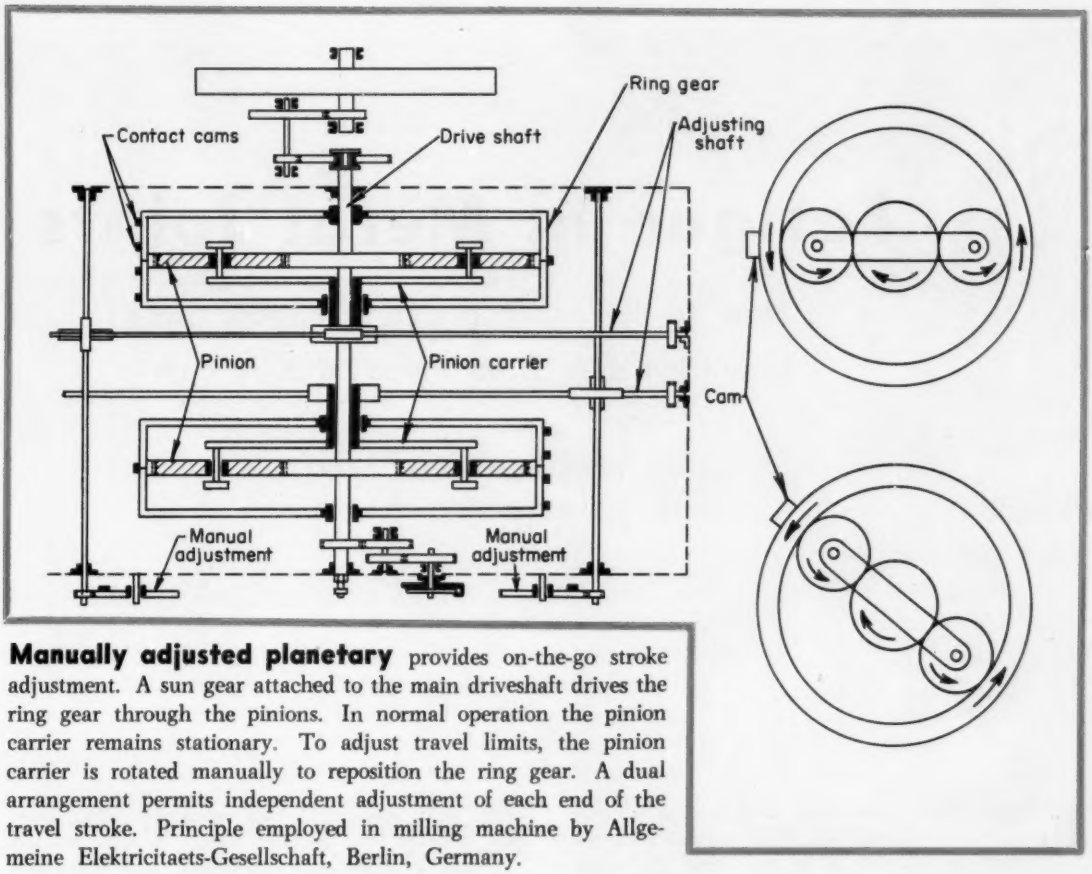
## SCANNING THE FIELD FOR IDEAS



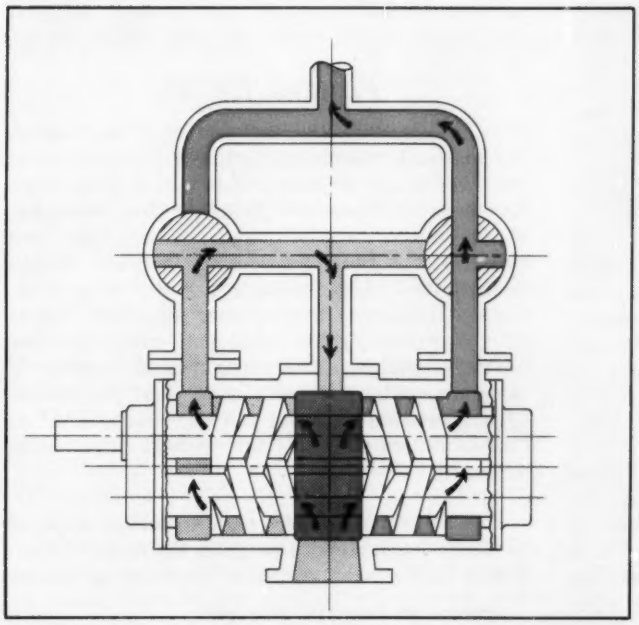

**Infrared pulses** regulate speed of hot wire in a rolling mill. A synchronous motor rotates a mirror to reflect heat rays to a photoelectric detector. The plate voltage of the thyratron is in phase with the synchronous motor voltage. If the hot wire is in the correct position, the output of the photoelectric cell does not actuate the thyratron. However, if the wire is out of position, the lack of synchronization between the photocell and the thyratron produces an error signal to regulate the speed of the rolling mill. Principle employed in mills designed by Allmanna Svenska Electriska A B, Vesteras, Sweden.

**Choice of force ratios** provides accurate measurement in several hydraulic-pressure ranges. At low pressures, a large sensing piston and a long lever arm produce a relatively large windup of a torsion rod. At higher pressures, the smaller pistons and shorter lever arm prevent excessive windup of the torsion rod. Measuring principle employed in a material tester by Deutsche Innen-und Aussenhandels-Gesellschaft, Berlin, Germany.






**Manually adjusted planetary** provides on-the-go stroke adjustment. A sun gear attached to the main driveshaft drives the ring gear through the pinions. In normal operation the pinion carrier remains stationary. To adjust travel limits, the pinion carrier is rotated manually to reposition the ring gear. A dual arrangement permits independent adjustment of each end of the travel stroke. Principle employed in milling machine by Allgemeine Elektricitaets-Gesellschaft, Berlin, Germany.



**Half of pump idles** during low-output operation. Valve configuration isolates idling end of screws from the line pressure. Principle employed in screw pump by Stothert and Pitt Ltd., Bath, England.

# Fatigue in Metal Joints

## How to determine design strengths using simplified data from modified *S-N* curves

## *1—Mechanical Joints*

EVEN when a structure is subjected to only a few repetitions of a load, fatigue problems must be considered in its design. A fatigue failure is a failure caused by more than one load application—whether as few as two, or as many as two billion. The objective in fatigue design is to keep the number of load applications that will cause failure above the number expected during the useful lifetime of the part. By definition, then, almost every static design becomes a fatigue problem because it does not fail under one load application. It is not a question of the existence of a fatigue problem; rather, it is a question of the severity of the existing problem.

This two-part series considers the design of an obvious region for fatigue-crack initiation within a structure—the joints. Joints are prime initiators of fatigue cracks because they not only disrupt stress flow and provide natural stress raisers, but they also alter homogeneity of the materials. Part 1 presents a general background of fatigue-design variables and specific fatigue-design information for evaluating endurance life of riveted and threaded joints. Part 2, in the next issue, discusses similar information for welded joints.

Many basic concepts of static loading are either inadequate or erroneous for repeated loading. For example, from the static-design viewpoint, ductility is generally considered a desirable property in a material. In the presence of stress concentrations, this property allows local yielding to take place under static loading. Under repeated loading, however, benefits from ductility cannot be fully realized.

Design and analysis techniques have been constantly improving, and higher static-strength materials have been developed. Consequently, safety factors have been lowered; the result has been increased fatigue problems. High fatigue strength does not always follow from high static strength, and good static design is not necessarily good fatigue design.

### *Fatigue Design*

As early as 1910, Bairstow[1] concluded that "neither the maximum tensile strength nor the yield stress bears any simple relation to the range of stress which may be safely repeated." Although more knowledge of the mechanisms of fatigue damage has been gained, no direct relationship between fatigue strength and static strength has yet been established. Laboratory fatigue tests frequently fail to give a true index for production structures—they are only reliable in indicating general behavior of materials under repeated loads. For this reason, high stress concentrations can be "designed in" or "manufactured in" a joint without their being suspected.

**Stress Ratio:** In practice, parts are seldom subjected to simple loading cycles in which the range of alternating load remains constant. Variations in loading

[1]References are tabulated at end of article.

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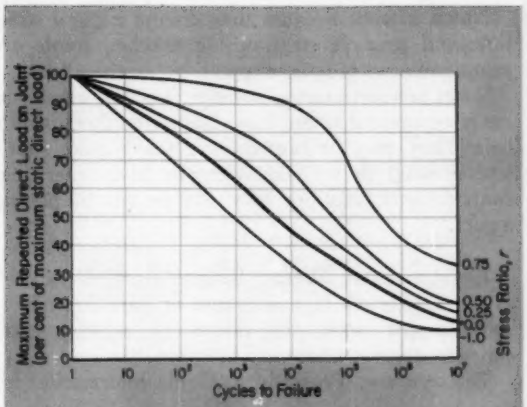



**Fig. 1—Approximate effects of stress ratio $r$ on fatigue strength of joints.**

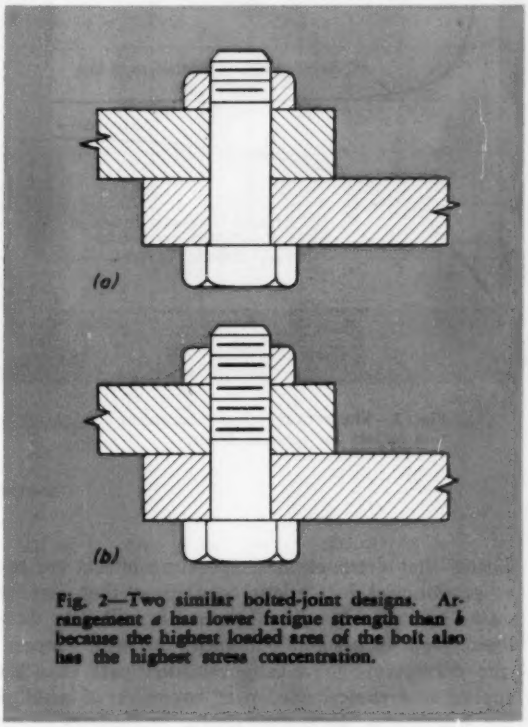



**Fig. 2—Two similar bolted-joint designs. Arrangement *a* has lower fatigue strength than *b* because the highest loaded area of the bolt also has the highest stress concentration.**

range generally occur which significantly affect the stress life of a part. A commonly used parameter in fatigue design is $r = S_{min}/S_{max}$, where $r$ = stress or range ratio; $S_{min}$ = the smallest numerical value of the stress in a cycle, psi; $S_{max}$ = the greatest numerical value of the stress in a cycle, psi. Although the positioning of $S_{min}$ and $S_{max}$ in the equation are determined by their absolute values, stress ratio $r$ is an algebraic ratio, and appropriate signs must be used (positive for tension, negative for compression).

For a given maximum stress, fatigue life increases with increase in stress ratio, $r$. For example, repeated stressing of a given material between 50,000 psi tension and 50,000 psi compression ($r = -1.0$) would reduce fatigue life more than repeated stressing of the same material between 50,000 psi tension and 0 psi ($r = 0$). The value of $r$ varies between $-1 \leqq r < 1$. The condition of $r = 1$ would, of course, represent a static stress rather than a cyclic one. Factors other than stress ratio that define a loading condition include stress range, stress type (sinusoidal, square wave, etc.), and the manner of loading (direct stress, rotating beam, etc.).

This article concentrates only on design for conditions of $r = 0$. However, Fig. 1 shows the approximate degree that other values of the stress ratio affect *S-N* curves for joints.

**Linear-Damage Theory:** Because loadings on a structure may be of a random nature, it is desirable to know how fatigue damage accumulates with cycles of load at a given stress ratio. Is the first cycle as damaging as the tenth or ten billionth? First approximations were that this was true, and a linear-damage theory, often credited to Miner,[3] was proposed. Although recent macroscopic[5] and microscopic[4] tests indicate the presence of various stages of fatigue-damage accumulation, the mechanism of the damage process is not entirely known. In the absence of such knowledge, the linear-damage

theory is probably the best tool available for predicting fatigue life of joints.

**Notch Effects:** Because they disrupt natural stress flow and produce stress-raising notches, joints are prime initiators of fatigue cracks.

Stress concentrations, however, are not always as easily recognized as are those due to the threads on a bolt. They may be caused by a much more subtle source—such as by embrittlement from interstitial contaminants resulting from the process of plating a part.

**Environmental Effects:** Fatigue strength as well as static strength of a structure or part depends to some extent upon the effects of environmental conditions.

*Temperature*: Presently available information indicates that detrimental temperature effects are not as pronounced for fatigue loading as they are for static loading. In the absence of sufficient data, therefore, it is reasonable to apply the same temperature corrections to a fatigue-loaded part that are applied to a static-loaded part, regardless of whether the corrections were established by fatigue or by static tests.

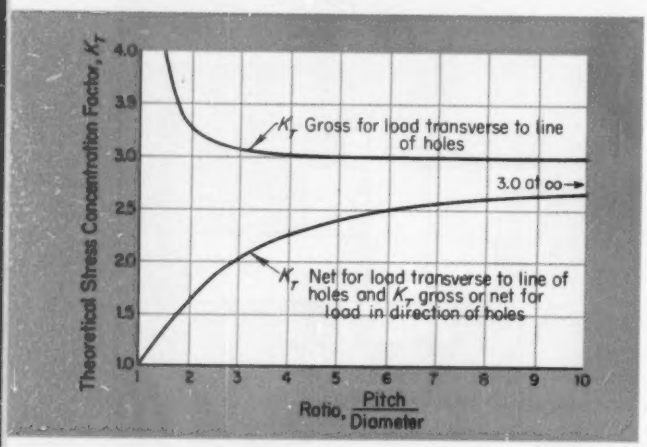



Fig. 3—Theoretical stress concentration factors for rows of holes.

*Corrosion*: Joints may be more subject to corrosion than the parent metal because fasteners tend to hold moisture and because the joint surfaces may be deprived of their natural corrosion-resistant layer. The heat-affected zone adjacent to a welded joint, for example, is particularly susceptible to corrosive agents.

When a joint is composed of dissimilar metals, electrolytic action may be an additional cause of corrosive action. Frequently a protective coating or a plating is used to prevent or to deter corrosion. The coating process must not promote pickup of hydrogen by the metal.

*Fretting*: Fretting fatigue is often confused with corrosion fatigue because each produces a cavitation-like effect. But under corrosion-fatigue conditions, fatigue and corrosion act jointly. By contrast, fretting fatigue, although often occurring in a corrosive environment, causes damage by microscopic rubbing of adjacent parts. In mechanical joints, metal surfaces are usually fastened together under high pressure and have a small amount of play between them. The friction of the two surfaces causes galling, tearing off of small metallic particles, or both, and fatigue damage follows. A lubricating coating of molybdenum disulfide reduces fretting fatigue significantly.

## *Mechanical Joints*

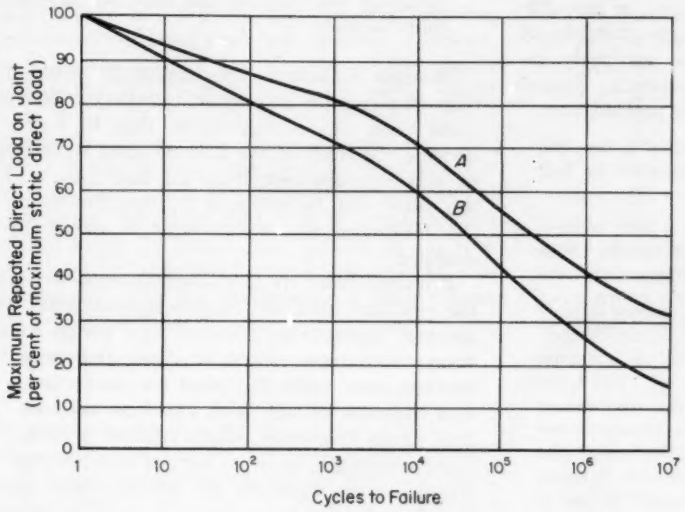
Photoelastic tests show that the theoretical stress concentration for an American Standard thread is 3.8. This factor can change, however, with different methods of thread forming, and in the over-all design of a threaded joint, stress concentration of the individual fastener is of minor significance. In addition, the change of section between the bolt shank and head often produces an even higher concentration; thus, the thread need only be as strong as the shank-to-head section.

A nut-and-bolt combination consists of a complex system of short cantilevers. Due to the elasticity of such a combination, the first thread of the bolt supports a large portion of the load—often one-third to one-half of the total. For this reason, it appears advisable to progressively increase clearance between nut and bolt threads up to a maximum at the first thread. Generally, this design is only practical on large column threads, although at least one manufacturer markets small fasteners whose design is based on this principle. Another approach uses a nut having a lower elastic modulus than that of the bolt to distribute the load to the bolt threads more uniformly.

**Thread Engagement:** A significant factor in fatigue design of mechanical joints is the location of the first bolt thread in a nut-and-bolt assembly. Because a single-groove shank has a higher stress concentration at the groove-to-shank transition than a multigroove shank, fatigue strength of the single-groove construction is lower. When the thread with the highest stress concentration is also the highest-loaded thread, Fig. 2*a*, the lowest fatigue life results. The threads in Fig. 2*b* continue farther along the bolt; thus the stress concentration and high load value are not coincident. The endurance limit of this joint may be as much as three times that of the joint in Fig. 2*a*.

**Tightening Pressure:** The most important single factor contributing to the fatigue strength of a bolted or riveted joint is the tightening pressure imposed upon the fastener. Generally, clamping

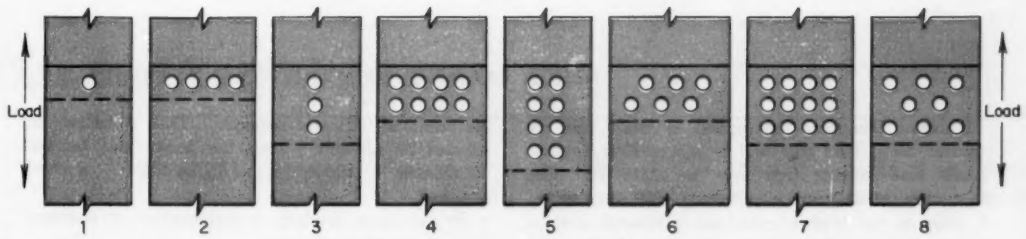
**Fig. 4.**




Curve *A*—High-Quality Fasteners: Applies to tightly installed protruding-head rivets and bolts. Bolts must be tightened by a calibrated method to 75 to 80 per cent of ultimate strength.

Curve *B* — Sandard - Quality Fasteners: Applies to protruding-head rivets and bolts in applications where tightness of installation cannot be fully assured. Also applies to countersunk rivets and heavy screw fasteners. For countersunk screws, use 50 per cent of fatigue life found from this curve.

**S-N Design Curves for Fatigue Loading**
(Stress ratio $r = 0$)




**Multiple-Fastener Groupings**

## Design Factors

Design factors that apply to typical fastener groupings are:

Group 1. Single fastener. Use appropriate curve directly. This group also applies in cases of pressure vessels or horizontal shear in beams—applications where the load is considered to come into the joint along its length rather than entirely at the ends.

Group 2. Additional fasteners in single row, transverse to load. Multiply fatigue-life value from curve by $(0.90)^{n-1}$, where $n$ is the number of fasteners.

Group 3. Additional fasteners in one row in direction of load. For two or three fasteners, use 80 per cent of fatigue life found from curves. For four or more fasteners, multiply fatigue life found from curve by $(0.90)^{n-1}$, where $n$ is the number of fasteners.

Group 4. Two parallel rows, transverse to load. Use 80 per cent of fatigue life for one row. (This is the same as applying the factor of Group 3 to Group 2.)

Group 5. Two parallel rows, in direction of load. Use 90 per cent of fatigue life for one row. (This is the same as applying the factor of Group 2 to Group 3.)

Group 6. Two staggered parallel rows, transverse to load. Use 90 per cent of fatigue life for one row.

Group 7. Three parallel rows of fasteners transverse to load. The third row adds little to the static strength of the joint because the outer two rows take most of the load. Under cyclic loading, however, readjustments of the load may occur which increase the fatigue resistance of this group over that of Group 4. Therefore, the third row may be the solution where two rows are sufficient statically, but where there is a question of fatigue. Use 60 per cent of fatigue life for one row.

Group 8. Three staggered parallel rows, transverse to load. Use 60 per cent of fatigue life for one row.

pressure should be at least 75 per cent of the ultimate strength of the material. Fatigue strengths of poorly tightened bolts or rivets are extremely inferior to those of well-tightened fasteners. Several common methods of measuring bolt preload are:

1. Measuring bolt elongation. This method is best, but is often difficult or impossible because of the bolt being inaccessible.
2. Using torque wrenches. This method is fairly reliable, but calibration is necessary. Because of friction, torque is not directly proportional to axial force.
3. Measuring angular twist of nut. This method is fairly reliable if the joint is well fitted and firmly clamped. A test nut is usually tightened as far as is deemed advisable before fracture, then backed off. This action brings the joint surfaces to a snug fit. The amount of twist required can be determined by testing two or three nuts to failure. The angular twist after snug fit is then controlled on production fasteners. Here too, amount of twist is determined by test or by shop or field experience. Alternatively, high-strength fasteners can be used to bring the joint to a snug condition. These fasteners would be replaced, of course, with standard ones after they have served their purpose.

**Multiple Fasteners:** The maximum stress at the edge of a circular hole in an infinitely wide sheet is three times the average stress, that is, $K_T = 3.0$. Because the effect of the hole on sheet stress is small at only one diameter from the hole ($K_T = 1.07$), the sheet can be trimmed at this dimension, and the maximum $K_T$ of 3.0 remains essentially unchanged.

If several holes are in a line transverse to the load, the resultant reduction in parent-metal cross section assumes importance, of course, as a design consideration. For rivets spaced at three diameters, stress concentration value $K_T$ based on gross cross-section area increases to only 3.12; based on net area (gross area minus hole areas), $K_T$ is reduced to 2.08, Fig. 3. Fatigue strength, as a per cent of static strength, increases as the fasteners are placed closer together; therefore, the fatigue problem becomes less important and the static ultimate strength more important under such conditions.

## DESIGN EXAMPLE

**Problem:** Determine the number of rivets that are required for a joint that will be subjected to a cyclic tensile load ranging from zero to 10,000 lb. The joint must be designed to withstand 1000 load cycles. A rivet of the type selected can withstand a static load of 2500 lb before failure. Maximum load on the rivets can be no more than 80 per cent of static ultimate strength. The width of the joint is such that a maximum of four rivets can be placed in one row. Full inspection of the joint for tightness cannot be made because of its physical location. For the example, the mode of failure in fatigue is assumed to be the same as that in static loading.

**Solution:** At 80 per cent of static ultimate strength, each rivet would be loaded to 2000 lb, and 10,000/2000 = 5 rivets. Therefore it is obvious that more than one row of rivets is required. Because a staggered arrangement (Group 6, Fig. 4) offers higher fatigue strength per rivet than a nonstaggered one (Group 4), the Group 6 arrangement is a logical trial.

A single row of three rivets (Group 2) has a fatigue life per rivet of $0.9^2 = 0.81$ times that of a single rivet (when the total load per rivet is the same). A second identical row (Group 6) would change the fatigue life of each rivet to $(0.9)0.81 = 0.73$ times that of a single rivet.

The design for this joint then must be based upon 1000/0.73, or 1370 cycles.

Curve *B* indicates that, for a fatigue life of 1370 cycles, the rivets cannot be stressed to more than 66 per cent of ultimate strength. This is below the allowed 80 per cent. Thus, the design load becomes 10,000/0.66 = 15,000 lb, and 15,000/2500 = 6 rivets required.

By the same method, a nonstaggered arrangement (Group 4) can be checked:

1. For one row of three rivets, $0.9^2 = 0.81$.
2. For two rows of three rivets $(0.8)0.81 = 0.65$.
3. Design for 1000/0.65 = 1540 cycles.
4. From curve *B*, maximum stress at 1540 cycles is 64 per cent. Design load then is 10,000/0.64 = 15,600 lb.
5. Rivets required: 15,600/2500 = 6.25. Seven must be used.

However, since seven rivets would include one row of four, the allowable stress must be rechecked on that basis. (The above calculation used rows of three.)

1. For one row of four rivets, $0.9^3 = 0.73$.
2. For two rows, $(0.8)0.73 = 0.58$.
3. Design for 1000/0.58 = 1725 cycles.
4. From curve *B*, maximum stress at 1725 cycles is 62 per cent. Design load then is 10,000/0.62 = 16,100 lb.
5. Rivets required: 16,100/2500 = 6.45. Seven rivets are required.

Thus, the nonstaggered joint arrangement requires one more rivet than the staggered joint. Since the odd number (seven) would indicate a staggered arrangement, the results of the first calculation (six rivets in two staggered rows) determine the design.

For holes in line with the load, the cross-sectional area does not change with hole spacing. However, both $K_T$ gross and $K_T$ net increase as the spacing increases and the stress-concentration curve follows the net curve for the transverse load. Again, closer fastener spacing increases fatigue resistance.

For a given lifetime, two fasteners used together have less than twice the fatigue-load capacity of one fastener. Similarly, two rows of fasteners have less than twice the fatigue-load capacity of one row. The reason for this is, of course, the unequal distribution of load to the fasteners in a group. Some ways to reduce these differences in load are:

1. Apply a static preload to the joint high enough to cause plastic flow and thus redistribute the load. This practice can be dangerous since the amount of preload necessary is about 80 per cent of ultimate.
2. Use mechanical fasteners that have different values of shear modulus. For example, the outer two rows of a three-row joint could be aluminum; the inner row, steel. This arrangement would distribute a greater load to the inner row which ordinarily receives less than its share of the load.
3. Space rivets differently in adjacent rows.
4. Vary the thickness through the joint by tapering, stepping, or other means.

**Test Results:** Although a search of the literature for fatigue data on joints produces much seemingly disassociated data for various materials, thicknesses, static strengths, and stress ratios, these data can be converted to a common base. Such a conversion for data on mechanical joints can consist of modified *S-N* curves in which the usual stress ordinate is replaced by maximum repeated direct load as a per cent of direct load strength of the joint (where the fasteners are in shear). Fig. 4 shows these curves and discusses their application to various mechanical-joint groupings. The design curves represent the lower range of an *S-N* band plotted from data of numerous investigators.

**Next article,** which concludes the series, discusses fatigue strengths and design of welded joints.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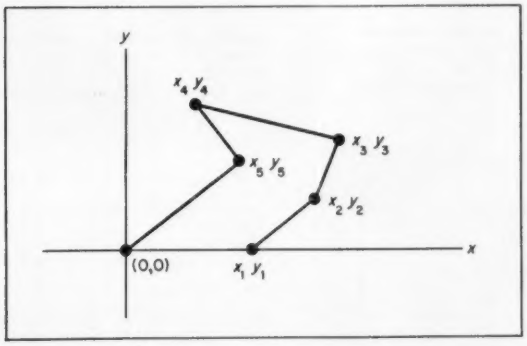
2. M. A. Miner—"Cumulative Damage in Fatigue," *Journal of Applied Mechanics*, Vol. 12, September, 1945, p. A-159.
3. R. G. Crum and E. D'Appolonia—"Damage of Titanium under Repeated Load," *Watertown Arsenal Report* No. 401/68-44, August, 1954.
4. M. S. Hunter and W. G. Fricke Jr.—"Effect of Alloy Content on the Metallographic Changes Accompanying Fatigue," *Proceedings ASTM*, Vol. 55, 1955, pp. 943-953.


# Tips and Techniques

## Area of a Polygon

The area of any polygon, regardless of the number of sides, can be found by solving a single equation. It is necessary only to determine the $x$ and $y$ values of the co-ordinates, as illustrated.

An example will illustrate the method. For a six-



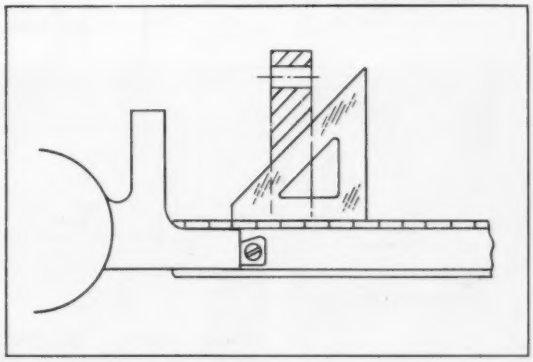

sided polygon, as shown,

$$A = \frac{1}{2}\,(x_1y_2 + x_2y_3 + x_3y_4 + x_4y_5 - x_2y_1 - x_3y_2 - x_4y_3 - x_5y_4)$$

For any other number of sides, the procedure is the same. Values are simply added to or subtracted from the expression in the parentheses.—JUSTIN V. PAULAUSKAS, *Elizabeth, N. J.*

## Cross-Hatching Guide

A useful cross-hatching guide can be made by squaring off the tip of a triangle, leaving a 1/8-in. flat. Simply line up the flat with the divisions on

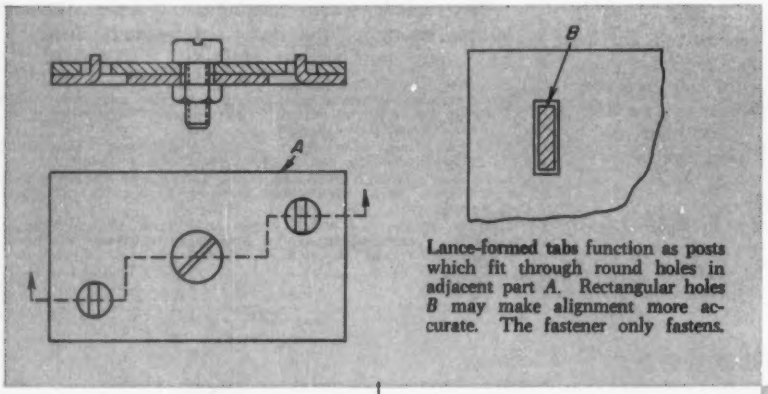


a drafting-machine scale to insure evenly spaced cross-section lines.—C. R. DUVALL, *designer, Bendix Friez Div., Baltimore, Md.*

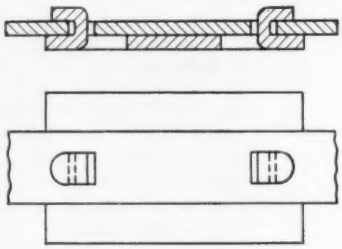
## Design methods for

# Alignment of Stamped Assemblies

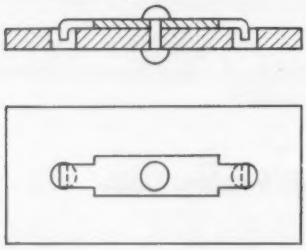
BUILT-IN accuracy of alignment is a primary consideration in the design of assemblies in which one or more members are stampings. Fastening means can be separate parts, or tabs and lugs. The latter, integral with the stampings, are folded into final positions. Fasteners might bear all, part, or none of the alignment function. Design details can be used singly and in combinations to achieve various degrees of alignment accuracy.



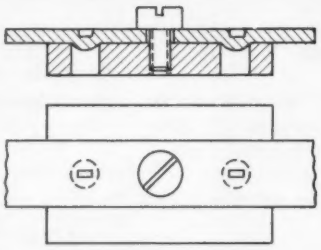

**Lance-formed tabs** function as posts which fit through round holes in adjacent part *A*. Rectangular holes *B* may make alignment more accurate. The fastener only fastens.



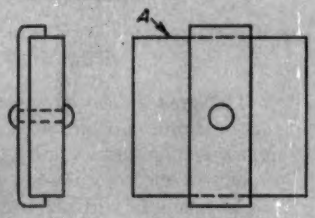
**Double-function tabs,** bent like staples, align and fasten adjacent parts.



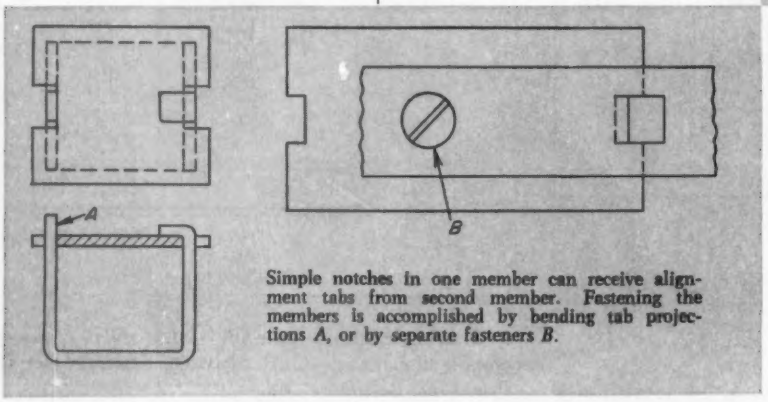
**Trimmed tabs,** at ends or sides of stampings, function as alignment posts the same as lance-formed tabs.



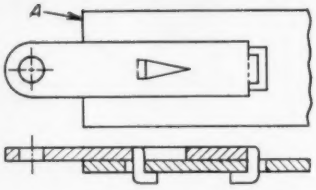
**Double louvering** — simultaneous slitting and stretching metal between parallel walls of a slot—can be used in combination with round holes.




**Contour of member *A* need not be interrupted when gripped between full-width lugs of second member and held by conventional fastener.**

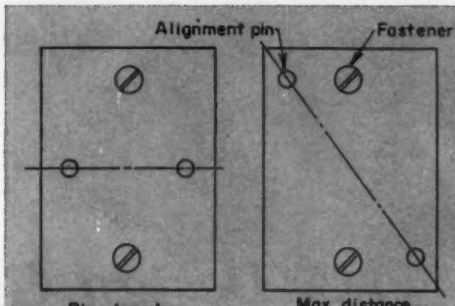



**Simple notches** in one member can receive alignment tabs from second member. Fastening the members is accomplished by bending tab projections *A*, or by separate fasteners *B*.

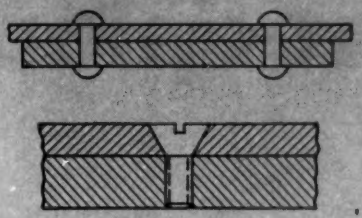



**Minimum preparation** of member *A* is punching of two holes which receive lance-formed lug and trimmed tab in stapled assembly.

**FEDERICO STRASSER**
Santiago, Chile

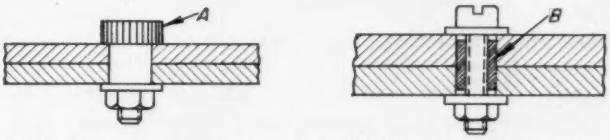



**Dowel pins,** cylindrical or tapered, align joint members with high accuracy, while fasteners only fasten. Pins also take lateral stresses. The greater the distance between pins, the greater the accuracy of alignment.

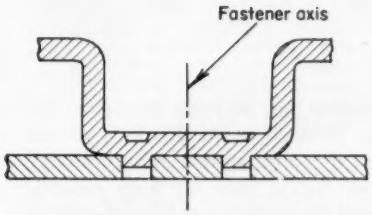


**Double-function fasteners,** such as rivets and screws, serve as means of alignment if high order of accuracy is not required. Minimum of two fasteners is required for each joint.

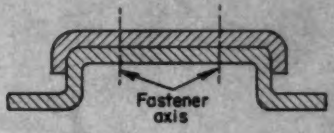
**Light-gage stock** can be joined and aligned by extruded bosses—hollow integral rivets.



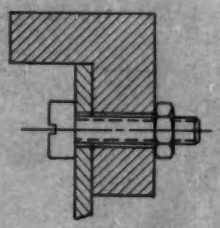

**Lack of space** may necessitate a double-function fastener, such as shoulder screw *A* or a length of precision tubing *B*.



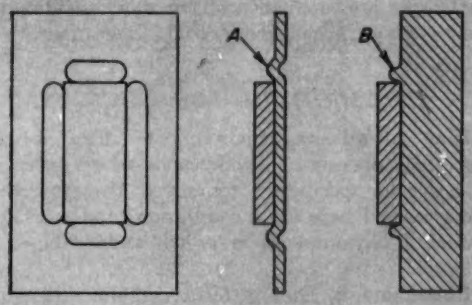

**Dowel extrusions**—partial extrusions—are formed in heavy stock by stamping operation. Aligned by these extrusions, joint can be held by separate fasteners.



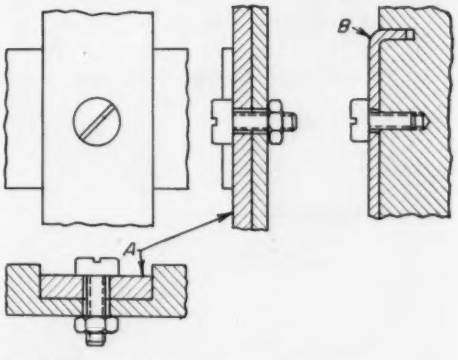

**Contours of workpieces** may be required to insure alignment of joints where assemblies do not provide enough space for alignment holes. Matched shapes of members is one method. Members are nested to insure matching.



**Abutments** in thick members serve, like slots, to align fastened stampings.




**Stamped rib** *A*, or cast rib *B*, can position second members.




**Slots,** milled in thick members, can receive and align entire section of thin member *A*, or projection *B* in stamped member.

# A Design Guide

# Precision

R. C. FROEHLICH

and

E. E. LEIRD

Micro Switch
Div. of Minneapolis-Honeywell Regulator Co.
Freeport, Ill.

**Part 1**

***Environmental Factors***

- Contaminants
- External Forces
- Temperature Extremes
- Physical Abuse
- Hazardous Atmospheres

***Installation Factors***

- Physical Size
- Field Adjustability
- Connections
- Serviceability

**Part 2**

***Mechanical Requirements***

- Actuating Motion
- Operating Speed
- Operating Travel
- Operating Forces

***Electrical Requirements***

- Circuitry
- Load

***Reliability***

- Repeatability
- Life

PRECISION snap-action switches are often the essential link between a mechanical system and an electrical-control system. They convert mechanical work or motion into electrical control, thus serving in place of human hands and eyes in controlling all kinds of machines and processes.

To help simplify selection of mechanically actuated switches, this two-part series presents a thorough guide to those factors and requirements that need to be checked to assure best results. Although attention is focused primarily on switches designed for broad commercial-industrial use, military and aircraft types are mentioned where their qualities suit them for specialized commercial applications.

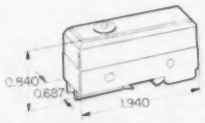
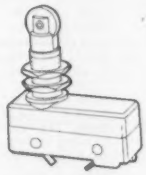
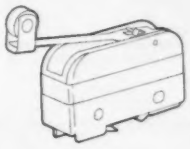
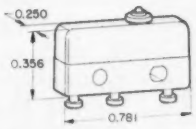
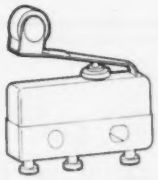
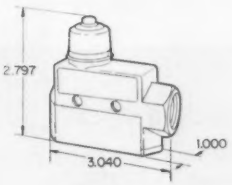
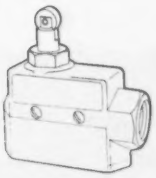
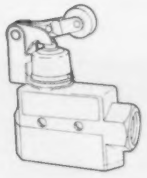
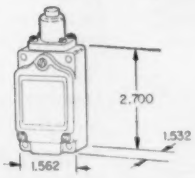
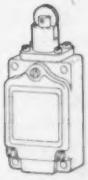
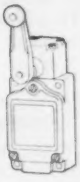
## *Environmental Factors*

How do different environments affect switches and their operation? What kinds of switches are available for specific environments? These questions are answered here for the environmental conditions commonly encountered in switch application.

**Contaminants:** Dust or other contaminants entering the basic switch (see Table 1) can cause high-contact resistance and may effectively open the circuit, especially where low current is present. Even relatively small particles lodging between the con-

# Snap-Action Switches

**Table 1—Types of Precision Snap-Action Switches**

| Switch Type | Push Plunger | Roller Plunger | Roller Lever |
|---|---|---|---|
| **Basic Switch** May have open-type contacts, but generally consists of a phenolic case with integral actuator, switching mechanism, and terminals. Case conforms to NEMA Type 1 enclosure.* |   |  |  |
| **Subminiature Switch (Basic)** Combines small size and light weight with high electrical capacity, precision operation, and long life. |   | |  |
| **Enclosed Switch** Uses metal enclosure with basic switch for one or more of the following reasons: 1. Protection of switching device. 2. Support for actuating mechanism. 3. Rugged mounting. 4. Provision for conduit attachment. Enclosures conform to NEMA Types 1 through 5.* |   |  |  |
| **Limit Switch (Enclosed)** Combines ruggedness and best sealing for industrial precision snap-action switches. Enclosures conform to NEMA Types 1 through 6.* |   |  |  |

Note: Switch names are not definitive but represent popular identification of such devices. For example, "limit switches," while often used to sense and limit motion, are also used as circuit or safety interlocks and in counting, sorting, and weighing functions.

*See Table 2.

**Table 2—Enclosure Types**

| Type | Name | Class | Group | Description and Uses |
|---|---|---|---|---|
| 1 | General Purpose | | | Protects against dust and light indirect splashing but is not dusttight; primarily prevents contact with live parts; used indoors and under normal atmospheric conditions. |
| 2 | Driptight | | | Similar to Type 1 with addition of drip shields or equivalent; used where condensation may be severe, as in cooling rooms and laundries. |
| 3 | Weather Resistant | | | Protects against weather hazards such as rain and sleet; used outdoors, on ship docks, for construction work, in tunnels and subways. |
| 4 | Watertight | | | Must exclude at least 65 gpm of water from a 1-in. nozzle delivered from a distance not less than 10 ft for 5 min; used outdoors, on ship docks, in dairies and breweries. |
| 5 | Dusttight | | | Provided with gaskets or equivalent to exclude dust; used in steel mills and cement plants. |
| 6 | Submersible | | | Design depends on specified conditions of pressure and time; used for submersion in water, as in quarries, mines, and manholes. |
| 7 | Hazardous Locations | I | D | Meets application requirements of the *National Electrical Code;* conforms with specifications of Underwriters' Laboratories Inc.; used for atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, acetone, benzol, lacquer - solvent vapors, and natural gas. |
| 9 | Hazardous Locations | II | F, G | Meets application requirements of the *National Electrical Code;* conforms with specifications of Underwriters' Laboratories Inc.; used for atmospheres containing carbon black, coal or coke dust, flour, starch, or grain dusts. |
| 9-A | Hazardous Locations | II | E | Meets application requirements of the *National Electrical Code;* conforms with specifications of Underwriters' Laboratories Inc.; used for atmospheres containing metal dust, such as aluminum, magnesium, and their alloys. |

From NEMA Standards Publication IC 1-1959.

tacts can prevent physical contact closure. Certain design features of a switch—high-contact force, contact wiping action, and contact shape and material—help prevent the opening of circuits from such causes.

Oil which enters the switch mechanism may be carbonized between the contacts by the heat of normal arcing during switch operation. The presence of carbon particles soon permits leakage currents to flow even when the contacts are fully separated. As carbonizing continues, leakage currents increase until overheating and ultimate destruction of the switch result.

Likewise, if moisture collects within the basic-switch case, electrical breakdown is likely to occur. Dust and abrasives cause either severe wear or jamming of the unsealed or exposed mechanisms.

The degree of exposure to contaminants determines which type of switch enclosure to select, Table 2. Even though enclosures have reached a high degree of perfection, limit switches should be located where they have as much protection from unfavorable conditions as possible.

Unlike most electrical equipment which can be placed in protected or remote locations, an enclosed switch or limit switch must usually be located right at the point of action where it may be exposed to such conditions as high humidity, splashing coolants and cutting oils, flying chips, abrasive dust, and corrosive atmospheres. However, a little care during machine layout can keep the switch out of the path of coolant spray or machining chips, Fig. 1. Often, a simple metal or transparent acrylic shield can also be placed between the switch and the direction of contaminant flow.

Grouping basic switches into a single enclosure provides a multitude of switching functions. Such an assembly, sometimes called a trip-post switch, facilitates trouble-shooting and permits location of the electrical control devices in an area protected as much as possible from contaminants. This arrangement can be employed only where it is practical to bring all pertinent mechanical movements from the machine to one area.

## Which Switch?

Precision electrical control switches are available in a variety of nonstandard styles, types, and configurations. For an outline of the total area, these switches may be classified into four general groups:

1. Mechanical switches are the most common and numerous of the four groups. Snap mechanisms open and close electrical contacts. They operate in any position. This group may be further divided into:
   - A. Mechanically actuated switches.
   - B. Manually operated switches, such as push-buttons, toggle switches, and rotary-selector switches.
2. Mercury switches use the flow of liquid mercury within a confined tube for making and breaking an electrical contact. These switches are position-sensitive and operate according to the amount of tilt or rotation of the tube.
3. Magnetic switches use magnetic attraction to cause electrical contacts to open or close.
4. Proximity switches use the phenomena of disturbance of an electromagnetic field to sense the presence of ferrous bodies. Electronic circuits then cause the necessary switching action to occur.

This article, presented in two parts, deals with group 1A—mechanically operated, precision snap-action switches.

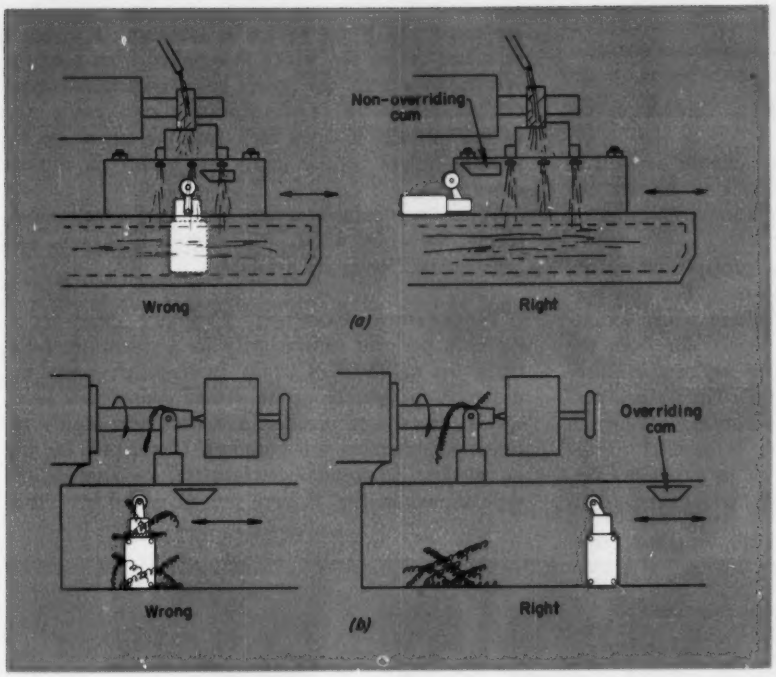



Fig. 1—Improved protection of limit switch from, *a*, coolant and, *b*, chips through relocation of actuating cam on the moving mechanism.

Fig. 2—Enclosed switch with gasketed cover and a synthetic rubber boot on the operating plunger.


Enclosed switches, Fig. 2, are adequate for an occasional splash of water, coolant, or cutting oil, and for moderate dust conditions. Well-sealed switches, Fig. 3, protect not only the switching cavity but also the actuator mechanism by preventing abrasive dust from wearing the moving parts. Such switches operate even when submerged and provide long life in unfavorable locations. To make their sealed construction complete, both enclosed and limit switches require that their conduit be adequately joined.

Corrosive fumes can be detrimental to switch life. Switch housings cast of aluminum and fitted with tight seals offer satisfactory protection to internal switch parts. Where acid fumes are dense and the switch cannot be located outside the affected area, hermetically sealed switches, Fig. 4, may be required. These units, developed primarily for use in airborne devices, are also useful where excessive humidity resulting from extreme temperature changes may cause condensation inside ordinary switches. Generally, these compact, light-duty switches are used in conjunction with a relay located outside the corrosive or moist atmosphere.

**External Forces:** If sufficiently severe, forces resulting from vibration, shock, impact, and acceleration may either momentarily separate the switch contacts or cause a false snap-over. Resistance to false operations varies with contact force (see *Definitions*), which is directly related to contact break distance. For example, typical values of break distances and acceleration forces under which precision snap-action switches perform satisfactorily are: 0.008 in., up to 40g; 0.020 in., up to 80g; 0.070 in., up to 200g. However, because forces arising from impact and vibration are not easily determined, care must be used

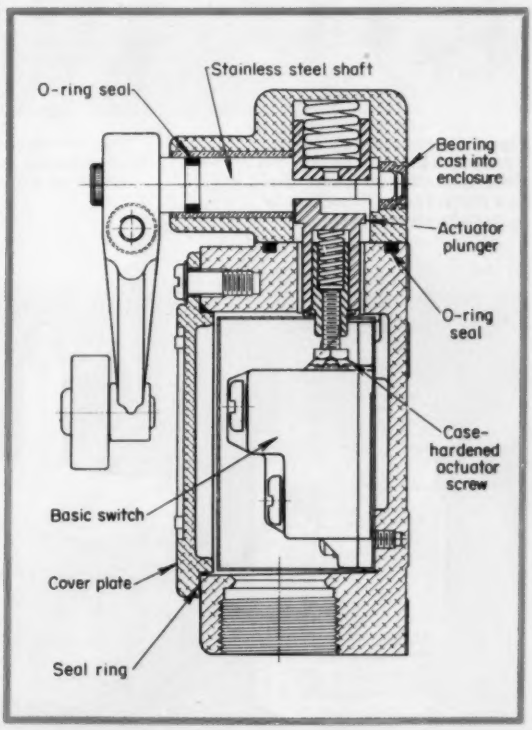



Fig. 3—Sealed switch with O-rings on actuating shaft and between actuator head and switch body. A seal is also used under the cover plate.

in applying these relationships to centrifugal acceleration values.

Vibration can result from tool chatter as well as from motors or motor drives. Shock or impact can result from such machine operations as indexing or stamping.

The effect of acceleration is greatest when the switch is near the point of snap-over. For this reason, vibration may become a problem when actuating motion is slow and never departs far from the snap-over point, as in pressure or temperature-sensing units. In such applications, satisfactory performance is often obtained by mounting the switch so that the plane of the spring is parallel to the direction of acceleration, Fig. 5, or by providing isolating resilience in the mounting. These precautions are important if the source of vibration is a motor or motor-driven fan which is supplied from a source synchronous with the power being switched—under critical conditions, such vibration can cause the switch contacts to open and close the circuit on alternate halves of the cycle and result in contact damage.

When particularly severe forces are encountered, special switches which use minimum masses and high-contact forces are available.

**Temperature Extremes:** Ordinary snap-action switches perform satisfactorily in ambient temperatures up to 180 F. Certain basic-switch units are designed to operate up to 400 F. Above this level, special metal and ceramic materials and highly refined construction are required. Developed for use on aircraft jet-engine afterburners, switches of the type shown in Fig. 6 have proved useful on indus-

Fig. 4 — Hermetically sealed, corrosion-resistant switch. A glass or metal seal under pressure prevents any "breathing in" of outside atmosphere.

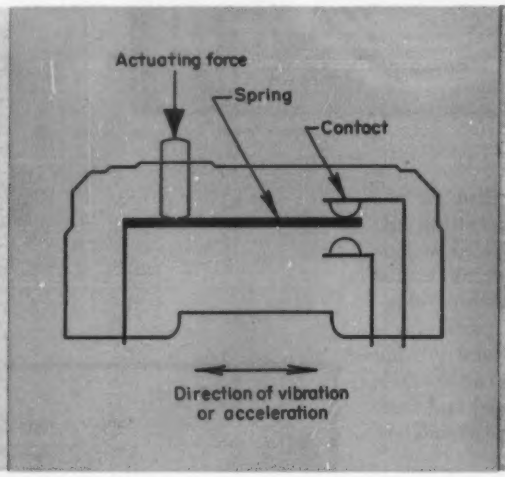



Fig. 5 — Recommended method of mounting switch to minimize effects of vibration on spring.

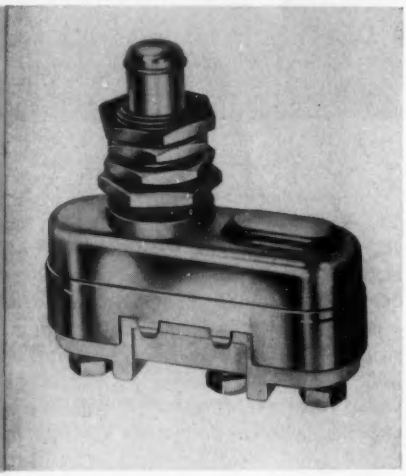


Fig. 6—Special switch design for precision operation in temperatures up to 1000 F.

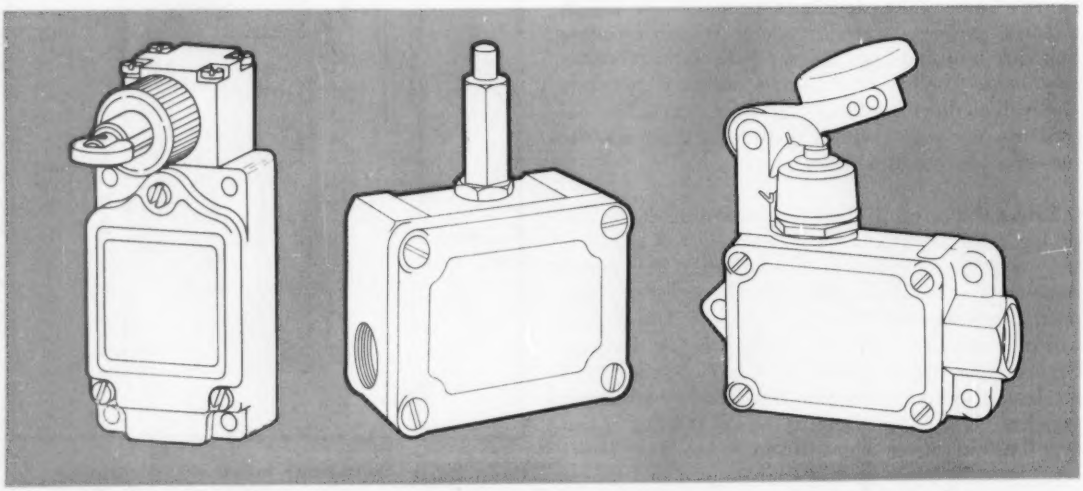


Fig. 7—Typical switches for applications in which housing or actuator may suffer physical abuse.

trial furnaces and other heating equipment.

At the other extreme, switches not having lubricants or rubber parts have been tested successfully at −321 F, the freezing point of liquid nitrogen. Because other factors, such as moisture or ice, are usually involved at such temperatures, each application should receive individual consideration.

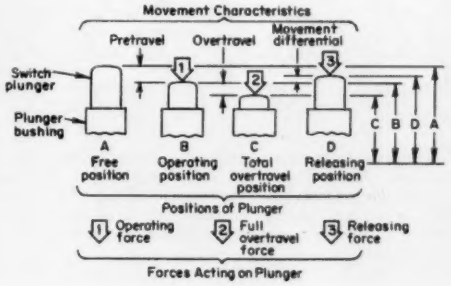
**Physical Abuse:** In addition to the severe acceleration forces produced by shock and vibration, location and environment may subject a switch to potential damage. If the operating device is not closely controlled or operates with varying degrees of force or travel, or if there is a chance the switch will be accidentally struck, enclosed switches that are suitably protected should be selected.

Sturdy housings having three or four ¼-in. mounting holes provide maximum stableness. Actuating mechanisms must also be ruggedly constructed, Fig. 7.

When basic switches are used without enclosures, certain precautions observed during installation help to assure accuracy of operation and long life of the switch. See *Recommendations for Mounting Basic Switches.*

**Hazardous Atmospheres:** Where the contact arc or a spark within the switch housing might ignite an explosive atmosphere, protective enclosures must be provided. In addition, explosionproof switches use special nonsparking bronze, plastic, or aluminum actuators.

Compact units are available, Fig. 8, and eliminate the need for building bulky and expensive enclosures in which to house electrical switches. Because of the requirements of their construction, most explosion-




## Definitions

**Snap action**—rapid motion of electrical contacts from one position to another.

**Precision snap-acting switch**—mechanically operated electric switch having predetermined and accurately controlled characteristics. Maximum separation between butting contacts is ⅛ in. (excludes blade and jaw and mercury-type contacts).

**Basic switch**—precision snap-acting switch of open, skeleton, or enclosed type.

**Momentary-contact switch**—switch which returns from operated to normal circuit condition when the actuating force is removed.

**Pretravel**—distance or angle through which the actuator moves from free to operating position.

**Operating position**—actuator position at which the contacts snap to the operated contact position.

**Overtravel**—movement of the actuator beyond the operating position.

**Total travel**—sum of pretravel and total overtravel.

**Contact force**—force exerted by a moving contact on a stationary contact.

**Releasing position**—actuator position at which the contacts snap from operated to normal contact position.

**Movement differential**—distance or angle from operating to releasing position.

From NEMA Standards Publication IC 3-1959

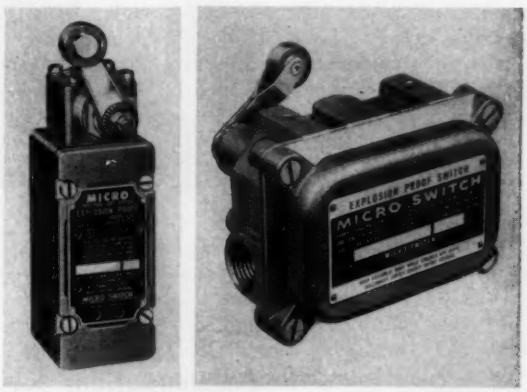



Fig. 8—Switch types approved by Underwriters' Laboratories Inc. for use in hazardous atmospheres (see NEMA Types 7, 9, and 9-A in Table 2).

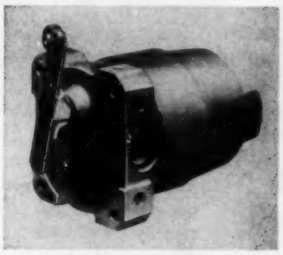


Fig. 9 — Completely sealed explosionproof switch which meets all requirements listed in Table 2.

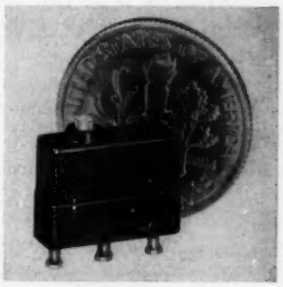


Fig. 10—Sub-subminiature precision snap-action switch with a rating of 7 amp (resistive current) at 125/230 v ac.


Fig. 11—Sealed, aircraft-type switch with total height of 2.355 in. and body diameter of 0.688 in.

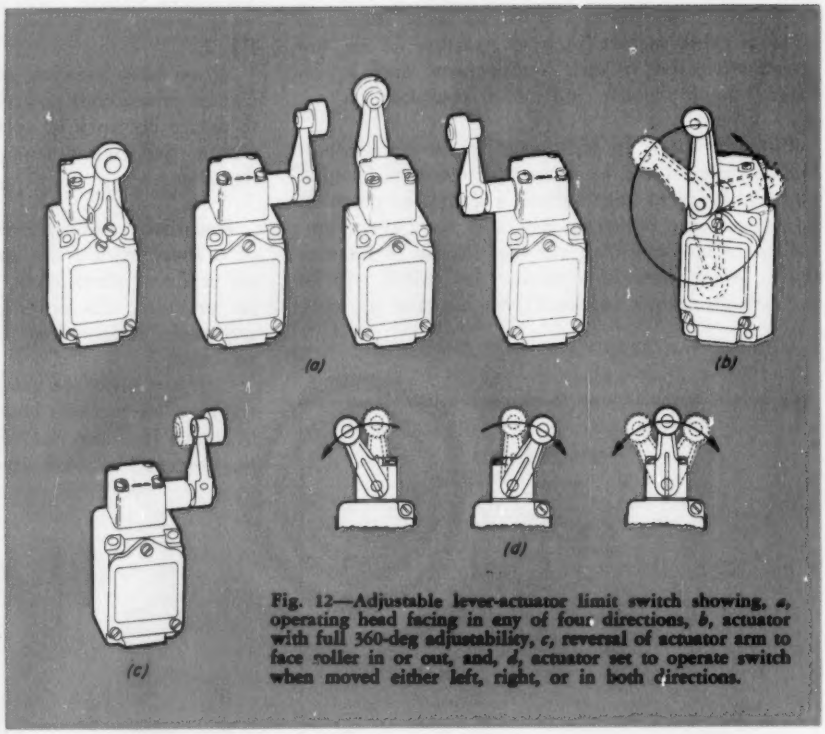
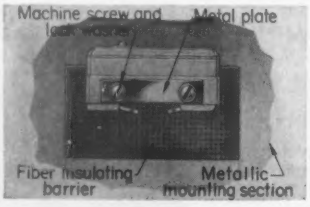
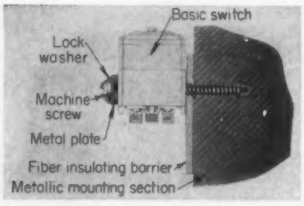
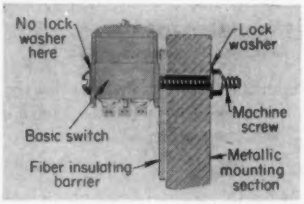



Fig. 12—Adjustable lever-actuator limit switch showing, *a*, operating head facing in any of four directions, *b*, actuator with full 360-deg adjustability, *c*, reversal of actuator arm to face roller in or out, and, *d*, actuator set to operate switch when moved either left, right, or in both directions.

## Recommendations for Mounting Basic Switches




1. When mounting the switch, use only through bolts or screws. Do not attempt to self-tap the plastic case by using screws having a diameter larger than the mounting hole.
2. To avoid cracking or distorting the switch case, use a flat mounting surface and do not overtighten the mounting screws.
3. When mounting to a metal surface, place fiber or glass-cloth insulation between switch and mounting surface to avoid grounding the lead wires.
4. When mounting to a thick section and into blind-tapped holes, place a metal plate against the exposed side of the switch and use lock washers under the heads of the mounting screws. The metal plate helps secure the switch to the mounting surface and prevents the lock washers from chipping the case. Instead of lock washers, drilled fillister-head screws may be used and wired together to form a secure fastening. In this case the metal plate may be eliminated.
5. When mounting to a thin section, place lock washers under the nuts on the other side of the section.

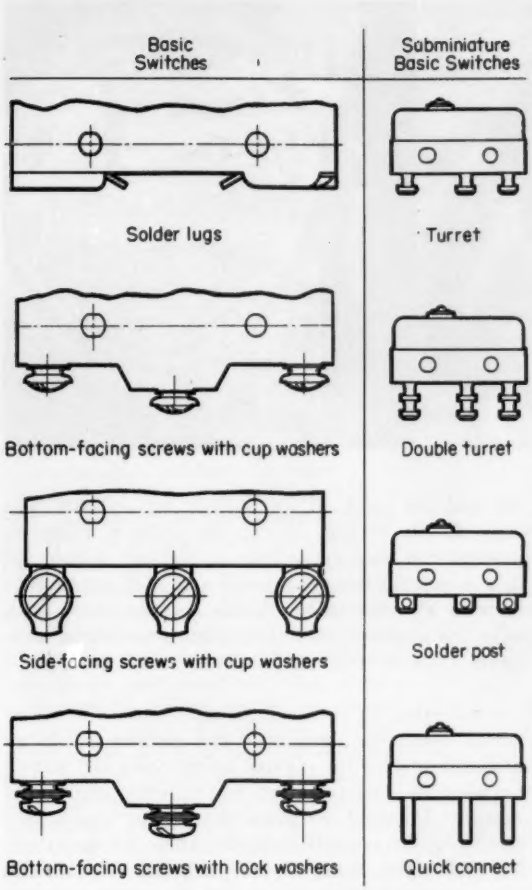



Fig. 13 — Basic and subminiature basic switches with available terminal styles.


Fig. 14 — Basic switch with enclosure for protecting and insulating the electrical connections.

Fig. 15 — Method using separable housing for gaining access to terminals of one type of enclosed limit switch.

proof switches are not sealed against liquids. One exception, however, is the type shown in Fig. 9.

## *Installation Factors*

Space available for installation may determine which type of switch is selected, particularly when this phase of an over-all design is left until last. Suitable electrical connections may further narrow the choice. Ease of installation and maintenance may suffer most in the effort to achieve an acceptable solution for the first two requirements. Following are some hints on available switch types and what they can do, even if functional concessions are not a necessity.

**Physical Size:** Envelope dimensions and configurations for representative switches are given in Table 1. When minimum space and weight are required, a "sub-subminiature" switch is available, Fig. 10. Its enclosure, which contains two integral mounting holes, measures 0.2 by 0.35 by 0.5 in. Miniaturized switches, however, may be difficult to mount, actuate, and wire and should not be specified without considering such possibilities. Some rugged, sealed, aircraft-type limit switches are smaller than the conduit to which they are connected, Fig. 11.

**Field Adjustability:** Many types of enclosed switches have actuators which permit a number of simple, mechanical changes to adapt them to particular jobs, Fig. 12. This feature, of course, greatly expands the available configurations of Table 1.

Other styles of limit switches offer their own types of built-in adjustments. Frequently, being able to adjust a switch on the job, either before or after it is installed, is a decided advantage. Also, a switch that can be adapted to a variety of mounting and operating requirements simplifies installation procedures.

**Terminal and Conduit Connections:** Basic switches are available with a variety of terminal configurations to suit the switch for solder, screw, wrap-around, or quick-connect assembly, Fig. 13. Basic switches may also be fitted with terminal enclosures to provide insulation and protection against shorting

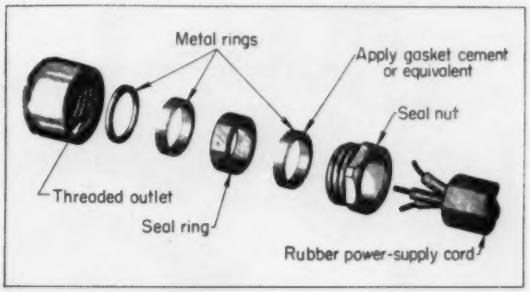



Fig. 16—Compression-type seal and strain relief for terminal wires contained in a synthetic rubber cable.

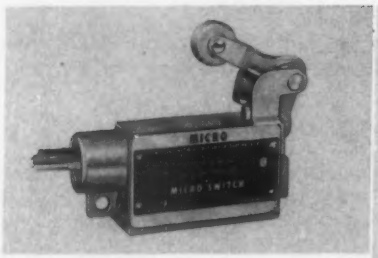


Fig. 17 — Completely sealed switch containing lead wires and having a compression seal inside the conduit hub.

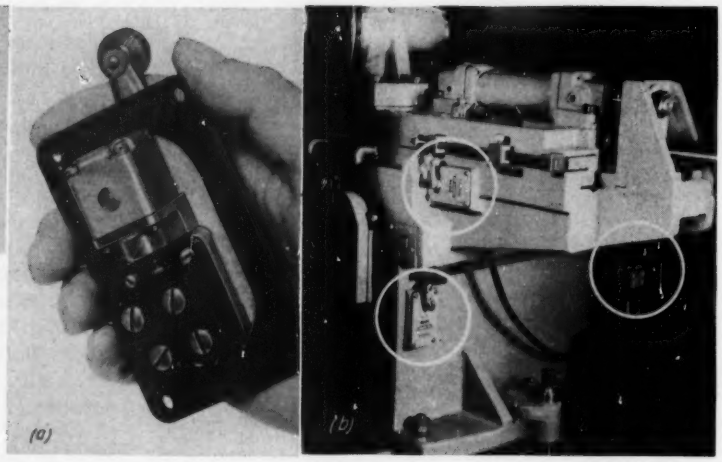


Fig. 18—Rear view, *a*, of cavity-mounted limit switch and front view, *b*, of three installations in a machine.

or grounding, Fig. 14. Terminals of the basic switching elements inside limit switches are usually exposed by removing a cover plate or bottom plate. However, design and size of the enclosure determine the method of access used, Fig. 15.

The cases of typical basic switches are molded of thermosetting phenolic plastic and have integrally molded terminal-screw inserts. Molded barriers and stepped design provide insulation and increased dielectric spacing for the terminal screws, which are generally fitted with cup washers to permit use of stripped wire ends or standard lug connectors.

Sealed switches are often contaminated by condensate or oil after installation because of an inadequate conduit connection. Sealed connectors, Fig. 16, should be used, and the conduit should be brought up from beneath the switch to prevent contaminants which collect inside the tube from draining into the switch. An alternative is to depress the conduit and provide a drain hole before the conduit enters the switch. Some switches are provided with preconnected lead-wires and a built-in compression seal, Fig. 17.

External conduit and connecting boxes can be eliminated with certain types of lever-arm, flush-mount limit switches. These switches have no housing and are designed for built-in applications. The type shown in Fig. 18 can be fastened either to mounts cast into a machine or through a hole cut in a panel. Such units provide a smooth appearance because all wire is run inside the machine. With only the arm and mounting plate protruding, minimum space is required for the switch.

**Serviceability:** To minimize the expense of unexpected shutdowns, machines and systems should be designed so that the control units which are subject to wear or damage may be replaced easily and quickly. Enclosed switches should be readily accessible and have sufficient clearances for easy service and replacement. Cover plates should face the maintenance access point.

A recent development that speeds replacement of switches is the plug-in type of limit switch, Fig. 19. All wiring is carried into a terminal housing which is permanently mounted on the machine. The switch housing contains the basic switch and its actuating mechanism and is plugged into the terminal block.

**Next article,** which concludes this two-part series, considers the electrical and mechanical aspects of selecting and applying precision snap-action switches.

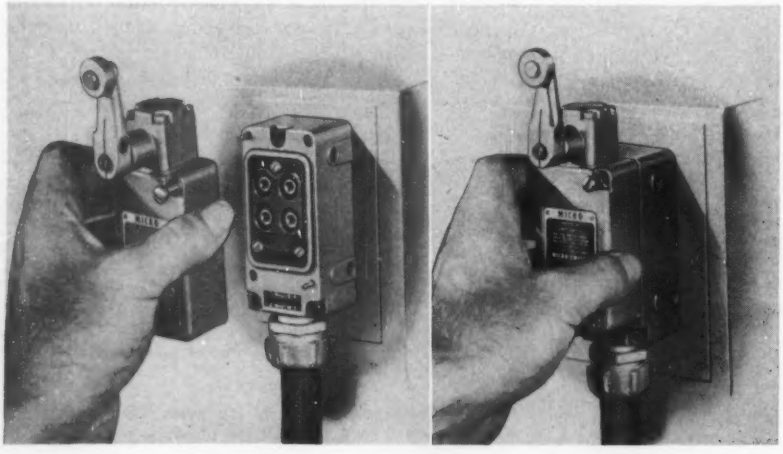
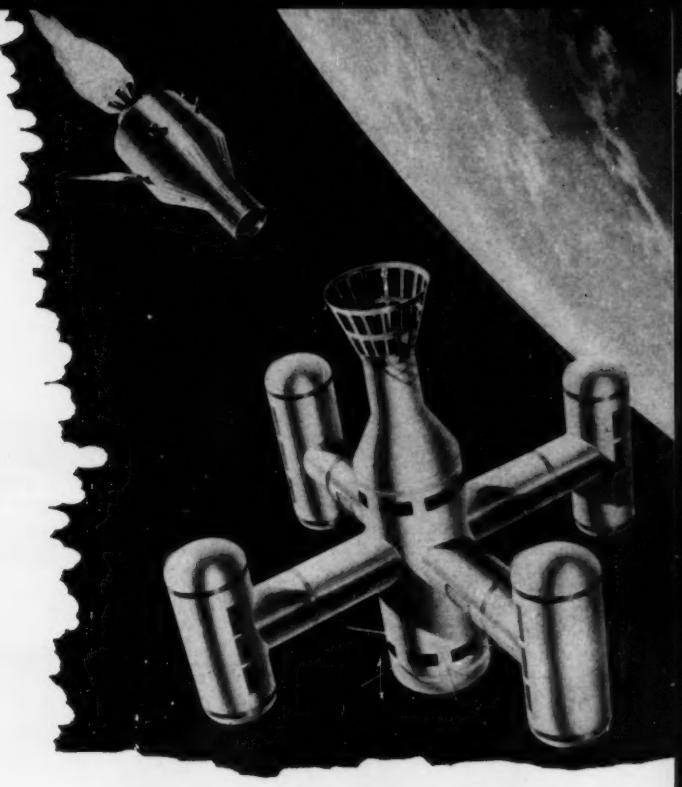
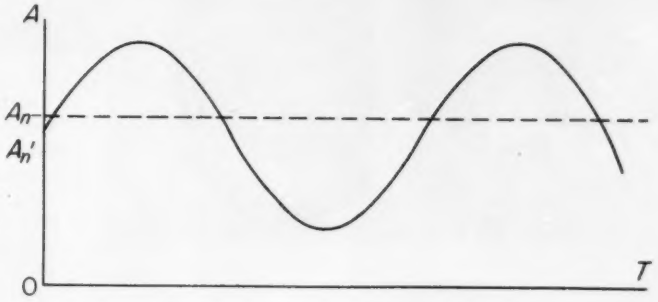


Fig. 19 — Plug-in limit switch designed for quick replacement. Wiring is permanently installed, and two No. 10 machine screws hold the two halves together.

# Satellite Centrifuge Tests Space Equipment

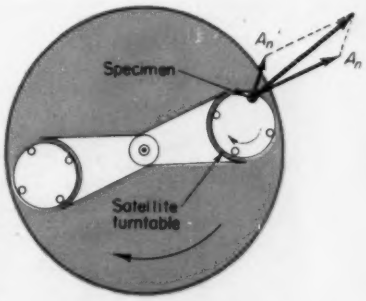


TELEMETERED DATA show that acceleration forces act in complex patterns on space vehicles and their payloads. Laboratory simulation of these conditions calls for more sophisticated test equipment than laboratories have been using heretofore. The standard centrifuge, for instance, has had to yield to especially designed units that imitate specific patterns of rise, dwell, and decay of fluctuating acceleration superimposed on other acceleration patterns. One very useful instrument for producing these superimposed loads is the dual centrifuge. One or more small turntables are mounted on the periphery of a larger turntable. The specimen is mounted on one of the satellite tables. Primary g loading is produced by rotating the large table. A sinusoidal loading pattern is superimposed by spinning the satellite table. The unit shown here is fairly small—the main turntable is 36 in. in diameter. Other units are being developed —up to a monster 100-ft-diam turntable which includes a pressurized temperature chamber, a small shaker, and a remote TV system for viewing specimens.

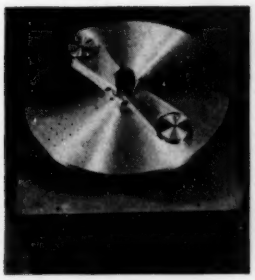


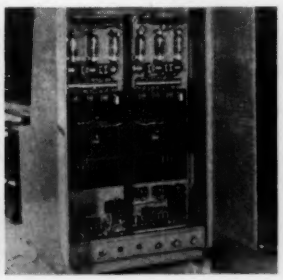

**SATELLITE** turntables are driven by independent motors through timing belts. Each satellite spindle has four slip rings to transmit data from instrumentation. Primary acceleration provided by the main turntable can reach 100 g. Sinusoidal frequencies superimposed by the satellite are as high as 30 cps. Each satellite turntable has a rated load of 2½ lb.

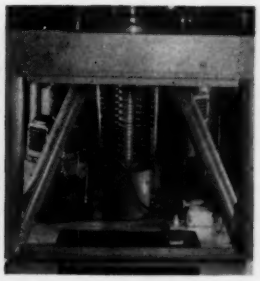
**SILVER-GRAPHITE** brushes operating on bronze slip rings faced with 1/16 in. of coin silver were found to produce an advantageous wear relationship for brush contacts. Good current flow is maintained by using three brushes per ring. In all, the main shaft supports 24 slip rings. Of these, three power rings are rated at 15 amp 220 v. The remaining instrument rings are rated at 50 amp 220 v; eight of them are used to power and monitor the auxiliary drive.




**SPINDLE SPEED** is monitored by four-decade electronic counters on both main and satellite tables. Gate times of 1/10, 1, and 10 sec are provided. Plus or minus one pulse represents ±1/600 rev per gate time on the main table; ±1/60 rev per gate time on satellite tables. DC-4 is one of a series of dual centrifuges being developed by Schaevitz Engineering, Camden, N. J.



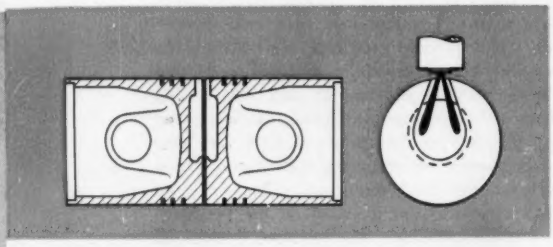




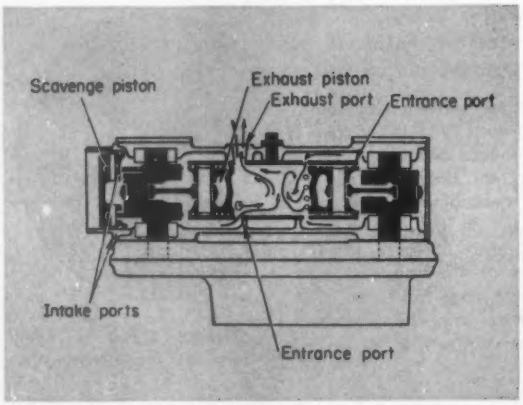
# Inclined Ports In Diesel-Outboard

TURBULENCE generated by the scavenging cycle mixes air and fuel in an unusual opposed-piston outboard motor. Combustion chamber is formed by matching cavities in the tops of two pistons; fuel is injected through matched grooves that form a channel from the injection nozzle to the combustion chamber. The scavenge system is a patented combination of uniflow and loop systems known as Vendaco.

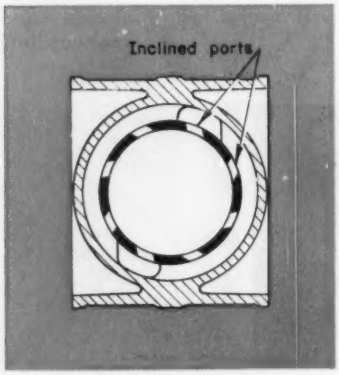
The diesel outboard is built by American Marc Inc., Inglewood, Calif. At present it is provided in a water-cooled version that generates 9¼ hp at 3500 rpm. Motors for other applications using similar design principles have been built by American Marc in air-cooled and water-cooled versions.



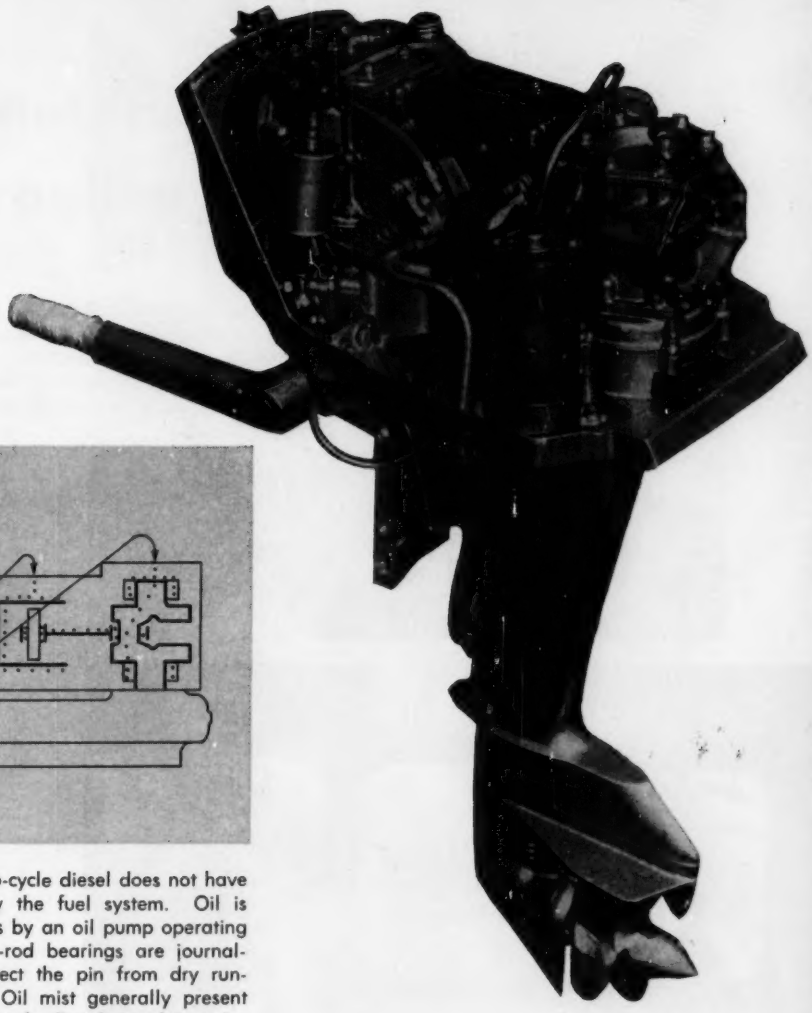
**MATCHING RECESSES** in the faces of two opposed pistons form a combustion chamber when the pistons are together. Fuel is injected through the channel formed by matching grooves leading to the edge of the pistons.

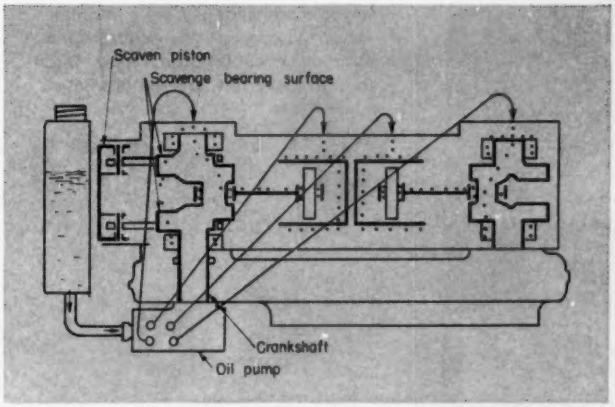



**COMPLEX SWIRL** pattern is produced by careful attention to port and channel arrangement. At the exhaust-port end, inlet and exhaust ports are kept well separated to avoid short-circuiting the fresh-air flow. Inclination of the port holes gives a swirl to entering air. Crankcase volume is kept as small as possible to produce a high air-delivery ratio. With a well-tuned exhaust and intake system, ram effects of the intake-air column produce delivery ratios greater than 100 per cent. Intake ports are 12 equally-spaced round holes in the scavenge cylinder.

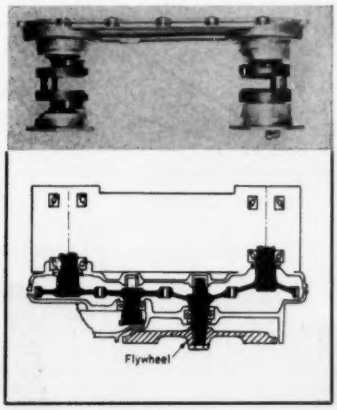


# Improve Flow Scavenge Cycle

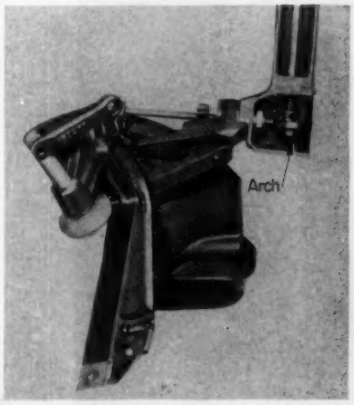




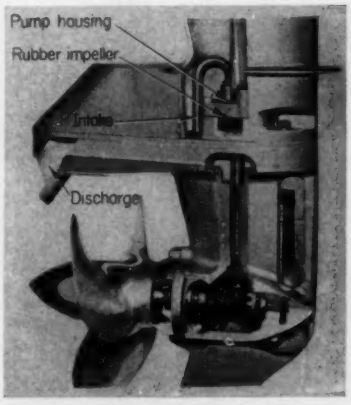

**UNLIKE** two-cycle gas engines, the two-cycle diesel does not have lubrication automatically provided by the fuel system. Oil is precisely metered to four critical points by an oil pump operating on one crankshaft. Scavenge piston-rod bearings are journal-type. Oil-impregnated bushings protect the pin from dry running during critical starting period. Oil mist generally present in the crankcase keeps bushings saturated. Developers have also experimented successfully with a Teflon-coated bearing.




**GEAR TRAIN** driving the flywheel from dual crankshafts provides timing for the shafts and drive outlets for accessories. Bearings for the scavenge piston are on the right-hand crankshaft.

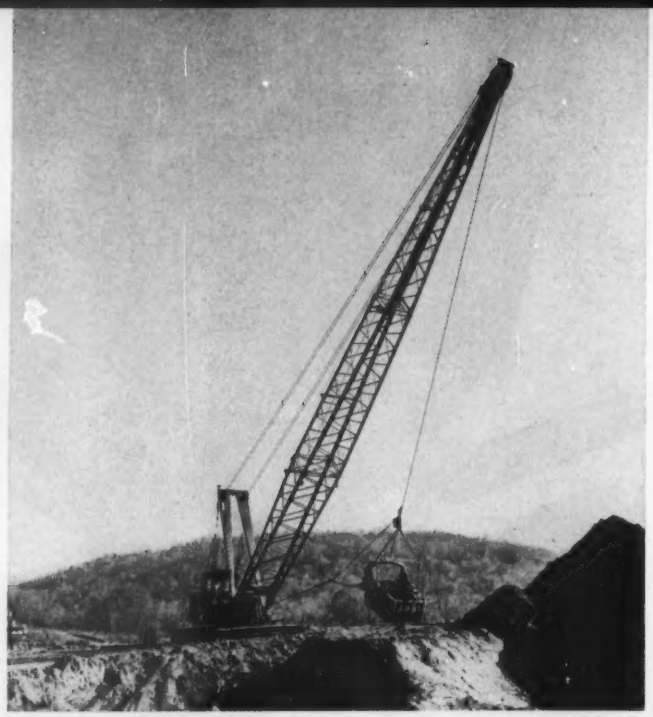



**CONTROLS** are conventional except that an arch over the throttle cam gives positive two-way control of the throttle linkage.

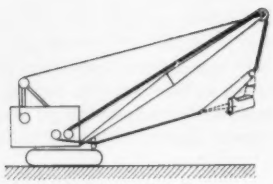



**MODEST COOLING** demands of the diesel make possible a very small cooling-water pump that improves streamlining of the lower leg. Impeller of the pump is rubber, and the pump is completely lined with stainless steel for salt-water use.

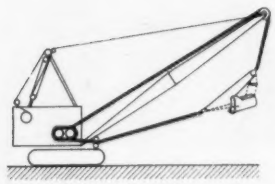
# Joysticks



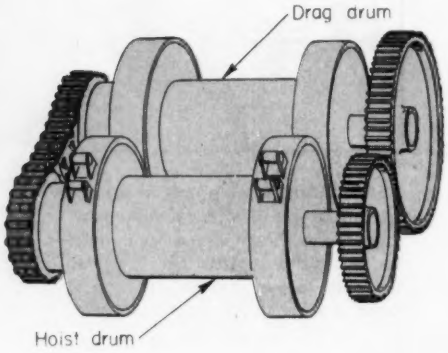
**DRAGLINE** excavator is one of a line of excavators built with the integrated-control principle by Manitowoc Engineering Corp., Manitowoc, Wisconsin. It's called the Manitowoc 4500 Vicon. Twin Disc torque converters are the transmission units.



Ordinary Dragline



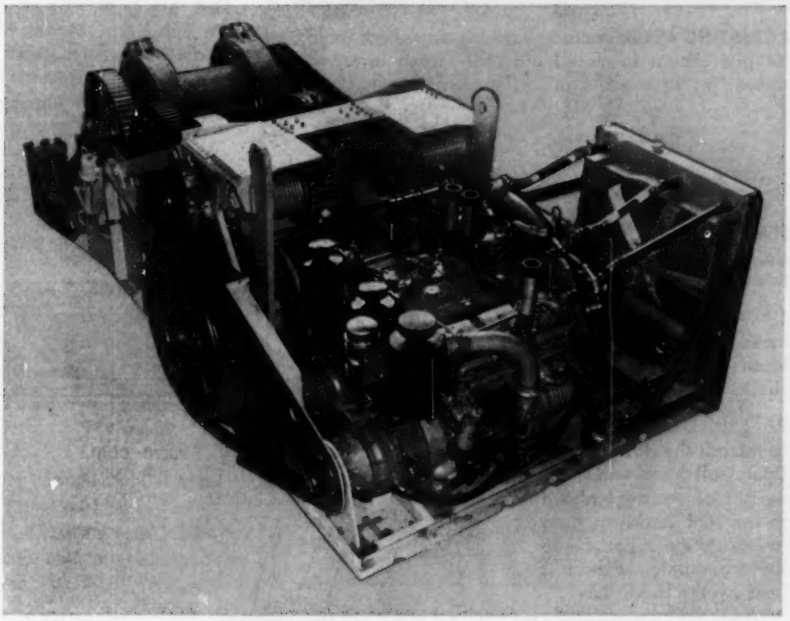
Vicon Dragline



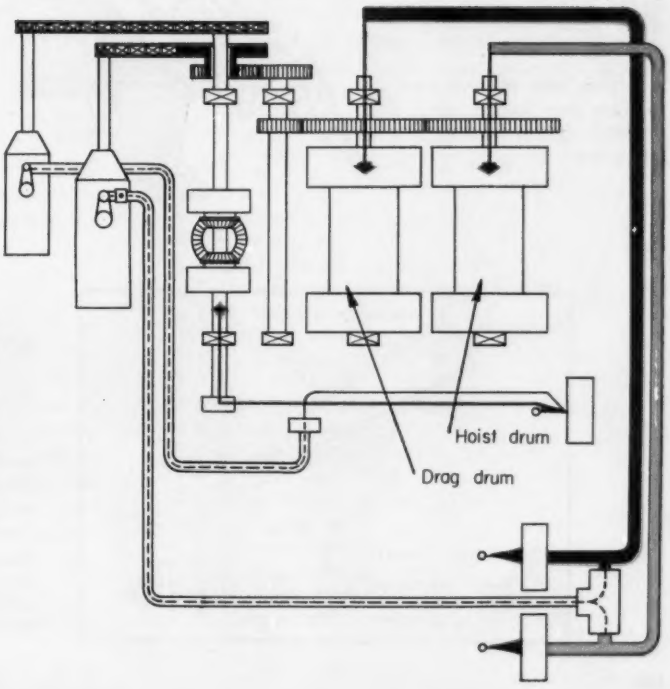

**JOYSTICKS CONTROL** clutching of drums and throttling of engines with one motion. The first ten degrees of motion admits air to clutch and throttle lines. Cluches are engaged, but pressure is not yet enough to move the throttle linkage. Further motion of the joystick admits more pressure and the throttle opens, allowing the engine to "pick up" under load. Hoist and drag drums are powered by one engine, swing of the crane by the second.

# Control Dual Motors In Dragline Excavator

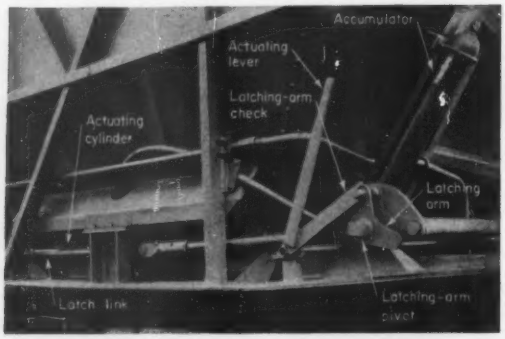
INTEGRATED operation of two engines gives a new dragline excavator unusual flexibility and speed when operating at peak power. Three-stage torque converters on both engines make it possible to position the bucket at low engine speed and apply power after the load is "set." This eliminates shock to cables and drums. Simple-to-operate joysticks combine clutch control and engine throttling in a single motion. Clutches are always applied at slow speed—another advantage of the dual engine system.



**UNIVERSAL** radiator serves both engines. Its capacity is prorated between the two engines as needed. When the smaller engine is used for travel, for instance, it has available the total cooling capacity of the system.




**INTERLOCK** of hoist and drag drums through a roller chain makes hoist and drag cables operate like an endless belt. To maintain a level bucket during the hoist-and-swing part of the cycle, the operator merely keeps the clutches engaged and the dragline pays out exactly in proportion to the takeup of the hoist line. For a free cast, he releases the clutches at a chosen moment, which allows the bucket to be cast well beyond the end of the boom.




**ACTUATING LEVER** operates latching-arm check (notch for pin) shown in closed position. Latch lever, not shown, fits square end of latching-arm piivot.

# Accumulator Slams Car Door After Coal Is Gone

AUTOMATIC opening and closing of trap doors in a railroad coal car takes a minimum of controls when the mechanism is actuated by a hydraulic accumulator. Weight of the payload, about 30 tons of coal, opens the doors when they are unlatched. Motion of the door opening stores energy in the accumulator. After car is emptied, doors are slammed shut by the accumulator. Door latches reset manually. Door-slamming actuator was developed by Olaer France SA, Bois-Colombes/Seine, France.

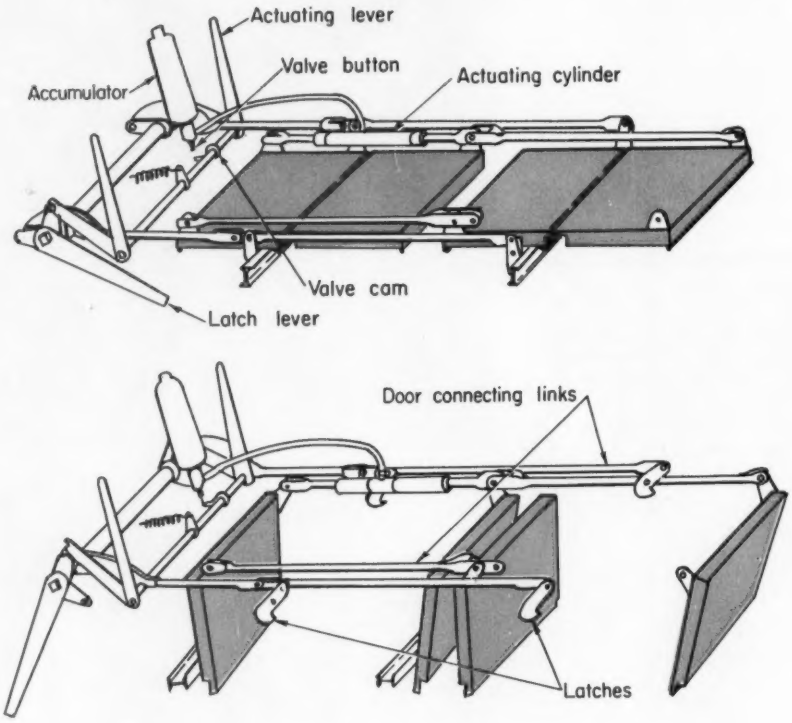
**STARTING** with doors closed, operations occur in this sequence:

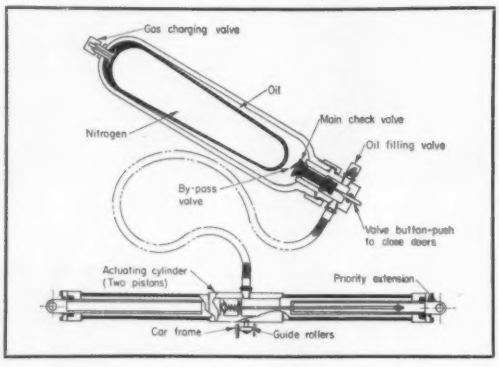
1. Actuating lever is moved back slightly to release the latching-arm check.

2. Latch lever is depressed to release the door latches. Doors fall open under the weight of the coal above them. Oil is driven from the actuating cylinder into the accumulator where it is held by the check valve.

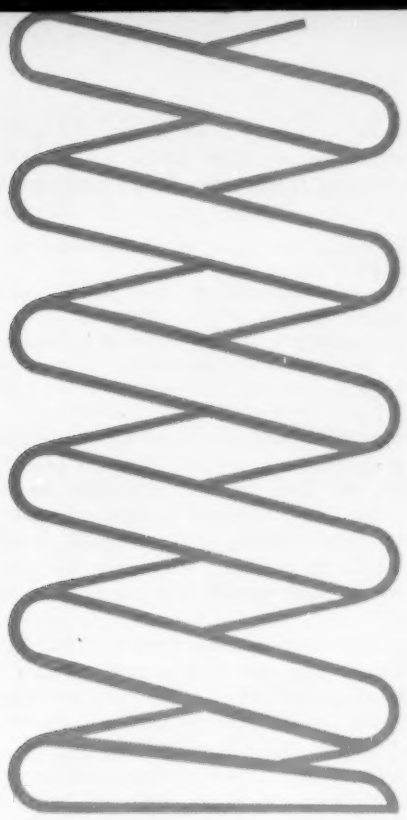
3. Actuating lever is pulled back to depress the check valve. Doors slam shut.

4. Latch lever is returned to close door latches, and the latching-arm check falls into place.




**PRIORITY** piston in the actuating cylinder is a fail-safe device to keep the wrong door from closing first, making a misfit at the closure. Accumulator is mounted button down over the valve cam on the actuating-lever shaft. Check valve admits oil when opening of trap doors forces it in, but retains it until the valve button is depressed, opening the bypass valve.



# a new direct procedure for helical spring design

**Introduced here, a stress-correction equation based on the Wahl factor automatically adjusts spring proportions for shear-load and coil-curvature effects.**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MERIT of the space-energy approach to compression-spring design has long been recognized. For a series of standard wire sizes, a series of spring configurations, and related space requirements, can be calculated to fulfill specific load-deflection conditions.

Details of this approach are covered quite thoroughly in the literature. However, the classic space-energy approach deals strictly with uncorrected torsional stresses. Tedious and time-consuming trial-and-error calculations, involving the Wahl factor,* may be required to obtain a stress-corrected configuration.

An equation, which includes the Wahl stress-correction factor, is the expression for the required active volume of spring material (see Nomenclature),

$$V = \frac{4UGK^2}{S_a{}^2}$$

But this equation is useless in the development of a stress-corrected spring configuration unless the correct spring index, and the corresponding Wahl factor, can be so predicted that the calculated (corrected) solid stress is equal to an allowable stress.

The design procedure presented in this article makes such a prediction possible and also makes the previous equation useful and practical. This procedure eliminates the tedious trial-and-error calculations usually required in the stress-correction adjustment of spring dimensions.

*A. M. Wahl—*Mechanical Springs*, The Penton Publishing Co., Cleveland, Ohio, 1949.

**Basic Considerations:** This analysis deals exclusively with the "space-energy" or load-deflection type of spring-design problem. The basic objective of design here is to determine the optimum space needed

**Nomenclature**

| | |
|---|---|
| $C$ | = Spring index |
| | $= D/d$ |
| $D$ | = Mean diameter of spring coil, in. |
| $d$ | = Wire size, in. |
| $F$ | = Total deflection (to solid height) in. |
| $F_2$ | = Deflection from working height to solid height, in. |
| $F_1$ | = Working-load deflection, in. |
| $G$ | = Torsional modulus, psi |
| $H$ | = Free height, in. |
| $h$ | = Solid height, in. |
| $K$ | = Wahl stress-correction factor |
| $N_c$ | = Number of active coils |
| $P$ | = Total load (at solid height), lb |
| $P_1$ | = Working load, lb |
| $R$ | = Spring rate or gradient, lb/in. |
| $S$ | = Solid stress, psi |
| $S_a$ | = Allowable solid stress, psi |
| $S_1$ | = Working stress, psi |
| $U$ | = Energy stored in spring, in.-lb |
| $V$ | = Active volume of material, cu in. |

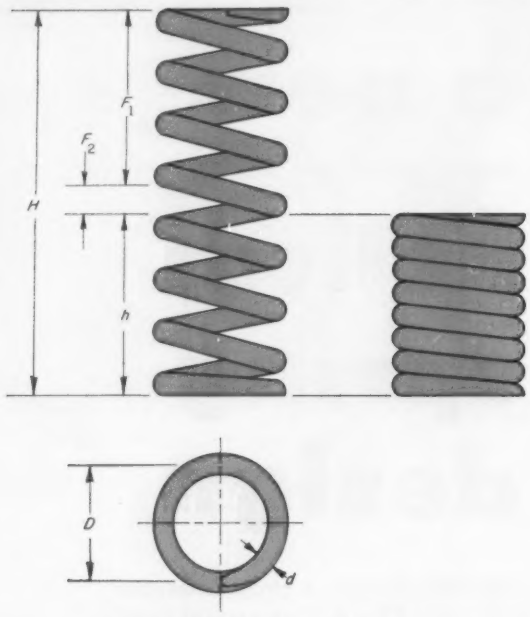


Fig. 1—Helical compression spring with squared and ground ends.

**Table 1—Design Equations**

Total Deflection:

$$F = \frac{F_1}{\frac{S_1}{S_a}} \tag{1.1}$$

or

$$F = F_1 + F_2 \tag{1.2}$$

Total Load:

$$P = \frac{F P_1}{F_1} \tag{2}$$

Stress-Corrected Mean Diameter:

$$D = \frac{d}{2}\left[\gamma - 0.365 + \sqrt{(\gamma - 2.365)^2 - 3}\right] \tag{3}$$

where

$$\gamma = \frac{\pi d^2 S_a}{8P}$$

Number of Active Coils:

$$N_a = \frac{F G d^4}{8 P D^3} \tag{4}$$

Solid Height:

$$h = d(N_a + 2) \tag{5}$$

Free Height:

$$H = h + F \tag{6}$$

Wahl Correction Factor:

$$K = \frac{4C - 1}{4C - 4} + \frac{0.615}{C} \tag{7}$$

Solid Stress:

$$S = \frac{8 P D K}{\pi d^3} \tag{8}$$

Spring Rate (Gradient):

$$R = \frac{G d^4}{8 D^3 N_a} \tag{9}$$

to handle the energy requirements of a spring without exceeding safe stress limits.

There are three basic design considerations involved:

1. Stresses incurred must be Wahl-corrected for shear load and coil curvature.
2. The Wahl-corrected solid stress must be equal to a predetermined limit.
3. The spring rate, or gradient, must be held constant for all configurations calculated to the given requirements.

**Design Procedure:** The usual procedure is to calculate a spring configuration based on pure torsional stresses, and then adjust it somehow, by trial and error, for Wahl-corrected stresses. Frequently, an average Wahl factor, $K$, is assumed to speed the trial-and-error process. Sometimes the adjustment is made through complicated nomograms, tables, or charts.

The procedure outlined here is direct. Start with a standard wire size and proceed directly through the equations in Table 1. The resulting spring configuration is automatically adjusted for Wahl-corrected stresses, and the solid stress will be equal to the preset limit. This stress limit can be set at the minimum torsional elastic limit for each standard wire size of a given material.

**Design Example:** Application of the procedure is best demonstrated by a typical design problem.

PROBLEM: Design a series of round-wire helical compression springs, Fig. 1, with a working deflection of 4.5 in. and a working load of 333 lb. The working stress is to be 60 per cent of the solid (design) stress. The solid stress is to be Wahl corrected and is not to exceed 115,000 psi. Ends are to be squared and ground (two dead coils). From this series of springs, the configuration giving a diameter versus length space requirement that best fits the over-all component design will be selected.

SOLUTION: Since load and deflection are proportional to stress and the working stress is to be 60 per cent of the solid stress, the total deflection from Equation 1.1 (Table 1) is

$$F = \frac{4.5}{0.6} = 7.5 \text{ in.}$$

From Equation 2, total load is

$$P = \frac{7.5(333)}{4.5} = 555 \text{ lb}$$

These initial steps are the same as for the conventional space-energy approach. The next step introduces the automatic stress correction that is the unique feature of this direct method. From Equation 3, using a standard wire size of $d = 0.250$ in., the stress-corrected mean diameter is

$$D = \frac{0.250}{2}\left[5.0856 - 0.365 + \sqrt{(5.0856 - 2.365)^2 - 3}\right]$$

$$= 0.8523 \text{ in.}$$

### The Stress-Correction Equation

From the standard stress equation which includes the Wahl factor (Equation 8, Table 1),

$$S = \frac{8PCK}{\pi d^2}$$

Note that stress $S$ varies not only as the spring index, $C$, or the Wahl factor, $K$, but also as their product, $CK$.

The relationship between solid stress and allowable stress is $S = KS_a$. The problem is to make $S = S_a$, using a reduced product $C_1K_1$. Therefore, let

$$C_1K_1 = \frac{CKS_a}{S}$$

But $S = KS_a$, which gives $C_1K_1 = C$, or

$$C_1\left[\frac{4C_1 - 1}{4C_1 - 4} + \frac{0.615}{C_1}\right] = C$$

Performing the indicated operations,

$$\frac{4C_1^2 - C_1}{4C_1 - 4} = C - 0.615$$

Let $k = C - 0.615$. Substituting in the previous expression gives the quadratic equation,

$$C_1^2 - \left(\frac{4k + 1}{4}\right)C_1 + k = 0$$

Solving this equation by the quadratic formula,

$$C_1 = \frac{1}{2}\left[k + 0.25 + \sqrt{(k + 0.25)^2 - 4k}\right]$$

Substituting $C - 0.615$ for $k$, and completing the square,

$$C_1 = \frac{1}{2}\left[C - 0.365 + \sqrt{(C - 2.365)^2 - 3}\right]$$

Since $D = dC$, multiplying the foregoing expression by $d$ gives the relationship which can be readily modified into the form of Equation 3 in Table 1. This equation can be used in initial designs to obtain a stress-corrected spring configuration directly. It can also be used in existing designs to reduce the stress to a desired limit by calculating a reduced, stress-corrected mean diameter directly.

**Table 2—Effect of Wahl Stress-Correction Factor on Spring Design***

| Wire Size, $d$(in.) | Mean Diam, $D$(in.) | Active Coils, $N_a$ | Solid Height, $h$(in.) | Free Height, $H$(in.) | Spring Index, $C$ | Wahl Factor $K$ |
|---|---|---|---|---|---|---|
| | | | Stress-Corrected Design | | | |
| 0.2500 | 0.8523 | 122.5475 | 31.1368 | 38.6368 | 3.4093 | 1.4917 |
| 0.2625 | 1.0476 | 80.2056 | 21.5789 | 29.0789 | 3.9911 | 1.4048 |
| 0.2830 | 1.4044 | 44.9822 | 13.2959 | 20.7959 | 4.9625 | 1.3132 |
| 0.3065 | 1.8797 | 25.8103 | 8.5238 | 16.0238 | 6.1329 | 1.2464 |
| 0.3310 | 2.4604 | 15.6545 | 5.8436 | 13.3436 | 7.4334 | 1.1993 |
| | | | Uncorrected Design | | | |
| 0.2500 | 1.2714 | 36.9217 | 9.7304 | 17.2304 | 5.0856 | |
| 0.2625 | 1.4718 | 28.9291 | 8.1189 | 15.6189 | 5.6069 | |
| 0.2830 | 1.8442 | 19.8632 | 6.1873 | 13.6873 | 6.5168 | |
| 0.3065 | 2.3429 | 13.3299 | 4.6986 | 12.1986 | 7.6441 | |

*Solid stress $S$ = 115,000 psi

The number of active coils is, Equation 4,

$$N_a = \frac{7.5(11.5)(10^6)(0.250)^4}{8(555)(0.8523)^3} = 122.54$$

Equation 5 gives solid height,

$$h = 0.250(122.54 + 2) = 31.13 \text{ in.}$$

and Equation 6 gives free height,

$$H = 31.13 + 7.5 = 38.63 \text{ in.}$$

From Equation 7, the Wahl stress-correction factor is $K = 1.492$.

Checking the solid stress with Equation 8,

$$S = \frac{8(555)(0.8523)(1.492)}{3.1416(0.250)^3} = 115{,}000 \text{ psi}$$

which equals the preset limit.

Checking the rate (gradient) with Equation 9,

$$R = \frac{11.5(10^6)(0.250)^4}{8(0.8523)^3(122.54)} = 74 \text{ lb/in.}$$

which equals the specified design condition ($R$ = 333/4.5 = 74 lb/in.).

**General Factors:** For the load-deflection type of spring design problem, where space requirements are to be determined and where stresses incurred are to be Wahl corrected, the direct approach through Equation 3 yields a stress-corrected spring configuration with a minimum of calculations. This stress-correction equation, which was developed primarily for compression springs, also can be readily adapted for extension springs where design is based on the same conditions previously outlined here.

The powerful effect of the Wahl stress-correction factor on spring design is clearly demonstrated in Table 2.

*Selecting small and medium-size*

# Internal-Combustion Engines

**Load torques and speeds are basic data in engine selection. They are converted to equivalent engine torques and duty cycles, to which are added allowances for altitude, temperature, and reserve power to establish engine size.**

**How rigidly an engine is mounted, how it is coupled to the load, and how it is controlled are related design details. Additional factors are electrical equipment, air cleaners and filters, protective methods, and fuels and lubricants. Each of these factors is discussed as it influences engine selection for specific applications.**

Single-cylinder, four-cycle engine powers a National triplex mower. Engine is air cooled and develops over 9 hp at 3600 rpm. It is started manually. A high-tension magneto with impulse coupling is completely weather sealed. Governor of fly-ball type is provided with two load speeds and idling control. A 6:1 clutch-reduction connects engine and vehicle. (Photo, courtesy National Mower Co.)

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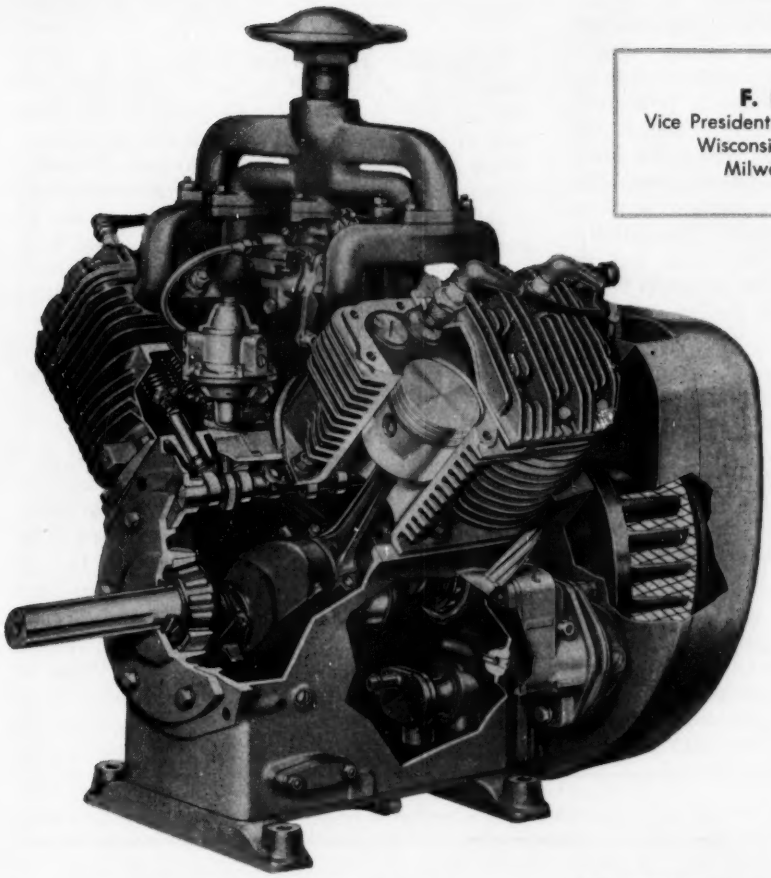


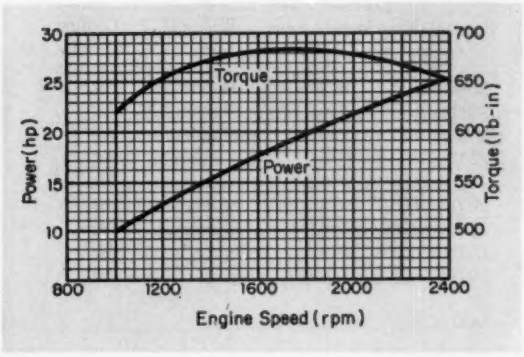



**Fig. 1—V-type, four-cylinder engine develops 25 hp at 2400 rpm. Pistons are aluminum, cylinders are nickel iron, and cylinder heads are aluminum die castings. Valve-seat inserts are Stellite. Valves are Stellite faced and equipped with positive valve rotators. Power curves show maximum dynamometer horsepower of engine, complete with cooling fan, muffler, and air cleaner, corrected to sea-level barometer reading of 29.92 in. at temperature of 60 F.**

ENGINE selection is more than taking the first available unit off the shelf and using it. Several factors may well be considered if satisfactory life and performance are to be realized. The most important factors to guide the selection of engines up to 60 hp in size are discussed here. Table 1 is typical of the variety of sizes and styles of engines currently available.

Power rating of an engine is usually defined over a range of speeds as in Table 1 and Fig. 1. Sometimes, however, only the power rating at maximum speed is stated. This is sufficient when an engine is being selected for operation at one speed only. In many applications, an engine is required to perform work at speeds less than maximum, as at half throttle. Under such conditions, engine speeds other than maximum may be critical. How to select an engine to meet variable power requirements is also covered here.

## *Determining Engine Size*

No internal combustion engine should be used which does not provide from 20 to 25 per cent reserve power. Certain trade organizations such as

the American Petroleum Institute require 35 per cent in reserve power.

If the power requirements of an application are fully known or can be predicted reliably, then a determination of engine size is simple. Power requirements plus allowances for reserve power, altitude, and temperature lead directly to engine size.

For every 1000 ft of altitude above sea level, power decreases approximately 3.5 per cent. The loss in power because of temperature rise is about 1 per cent per 10 deg F above 60 F. Theoretically, power is increased as temperature drops, but no allowance is made at temperatures below 60 F, because apparent gains are wiped out by increased friction losses.

Example: What size of engine is required to deliver 12 hp at 5000 ft altitude and 85 F? Calculations are:

| | |
|---|---|
| Delivered horsepower | = 12 |
| Altitude correction: 0.035 (5) (12) | = 2.1 |
| Temperature correction: 0.01 (2.5) (12) | = 0.3 |
| Reserve power: 0.25 (12) | = 3.0 |
| Engine size, hp | 17.4 |

In the design of new machinery and equipment, power requirements at maximum speed are frequently underestimated. More often perhaps, the power requirements at speeds other than maximum are not estimated at all. Moreover, it is improbable that an engine is available that delivers exactly the horsepower determined by calculations. Thus, in rounding off calculated engine size into available engine size, recommended design practice is to select an engine that delivers more horsepower, rather than less, at the calculated speed and conditions of operation.

**Comparison with Electric Motors:** If an electric motor is to be replaced by an internal-combustion engine, consideration must be given to the difference in rating methods of the two sources of power. While both electric motors and internal-combustion engines are sold on the basis of horsepower, each is rated upon a different basis. Electric motors deliver from 25 to 50 per cent more than rated horsepower whereas internal-combustion engines should not be run at more than 75 to 80 per cent of rating. When these differences are taken into account, the internal-combustion engine should be 67.5 per cent larger than the electric motor it replaces. As a rule of thumb, a ratio of 2:1 is widely accepted.

**Method of Cooling:** Air and liquid-cooled engines are rated on different bases. An air-cooled engine must be tested with the full cooling system intact; hence, the advertised power of an air-cooled engine is the available shaft horsepower, Fig. 1.

In general, liquid-cooled engines are tested and ratings established under conditions which include a minimum of power-absorbing auxiliary equipment, such as, radiator, fan, and water pump. When information is not available regarding whether or not these units are included or if the power consumption of them must be estimated, an average deduc-

**Table 1—Typical Engine Sizes and Characteristics**

| Power (hp) | No. of Cylinders | Mounting Position | Speed Range (rpm) | Weight Ratio (lb/hp) | Principal Material | Cooling Medium |
|---|---|---|---|---|---|---|
| 1.25 to 2 | 1 | Vertical | 2200 to 3600 | 9.25 | Aluminum | Air |
| 1/25 to 2 | 1 | Horizontal | 2200 to 3600 | 10.5 | Aluminum | Air |
| 1.3 to 2.25 | 1 | Horizontal | 2200 to 3600 | 10.2 | Aluminum | Air |
| 1.5 to 2.5 | 1 | Vertical | 2200 to 3800 | 6.6 | Aluminum | Air |
| 1.5 to 2.5 | 1 | Horizontal | 2200 to 3600 | 8.6 | Aluminum | Air |
| 1.7 to 3 | 1 | Horizontal | 2200 to 3600 | 8.3 | Aluminum | Air |
| 1.9 to 3 | 1 | Vertical | 2200 to 3600 | 6.3 | Aluminum | Air |
| 1.7 to 3.4 | 1 | Horizontal | 1800 to 3600 | 18.6 | Iron | Air |
| 2.5 to 7 | 1 | Vertical or Horizontal | 1600 to 3600 | 10.8 | Iron | Air |
| 4.7 to 9.2 | 1 | Vertical or Horizontal | 1600 to 3600 | 11.9 | Iron | Air |
| 7.7 to 12.5 | 1 | Horizontal | 1600 to 3200 | 14.4 | Iron | Air |
| 10 to 18 | 2 | Horizontal | 1600 to 3600 | 12.3* | Iron* | Air |
| 10 to 20 | 4† | Horizontal | 1200 to 2600 | 14.5§ | Iron | Liquid |
| 14 to 30 | 4 | V | 1200 to 2800 | 10.3* | Iron* | Air |
| 15 to 28 | 4† | Horizontal | 1200 to 2600 | 10.4§ | Iron | Liquid |
| 25 to 37 | 4 | V | 1400 to 2400 | 11.1 | Iron | Air |
| 21 to 36.5 | 4† | Horizontal | 1200 to 2400 | 11.4§ | Iron | Liquid |
| 31 to 54.5 | 6† | Horizontal | 1200 to 2400 | 10.1§ | Iron | Liquid |
| 43 to 56.5 | 4 | V | 1400 to 2200 | 13.7 | Iron | Air |

*9.5 with crankcase and other parts of aluminum.
†Liquid-cooled engines are listed in terms of bare horsepower. Deduct 12 to 15 per cent from power listed for radiator fan, pump, and other auxiliary units.
§Weight based upon "dry" engine, that is, without auxiliary units as radiator, fan, pump. Actual weight installed is between 50 to 100 per cent greater.

tion of 12 per cent from the advertised horsepower rating is reasonable, Table 1.

Optional use of air and liquid as the cooling medium at about 12 hp has led many people to conclude that air cooling is suitable for light-duty engines only. This premise is not supported by fact. Air-cooled engines are commercially available up to 60 hp which incorporate every feature, such as Stellite-faced valves, valve rotators, and replaceable valve guides, found in only the most expensive liquid-cooled engines. A properly designed and installed air-cooled engine can and does compete favorably with liquid-cooled engines under any circumstance. Further, an air-cooled engine has distinct advantages in weight, simplicity, and tolerance for unusual environmental conditions such as

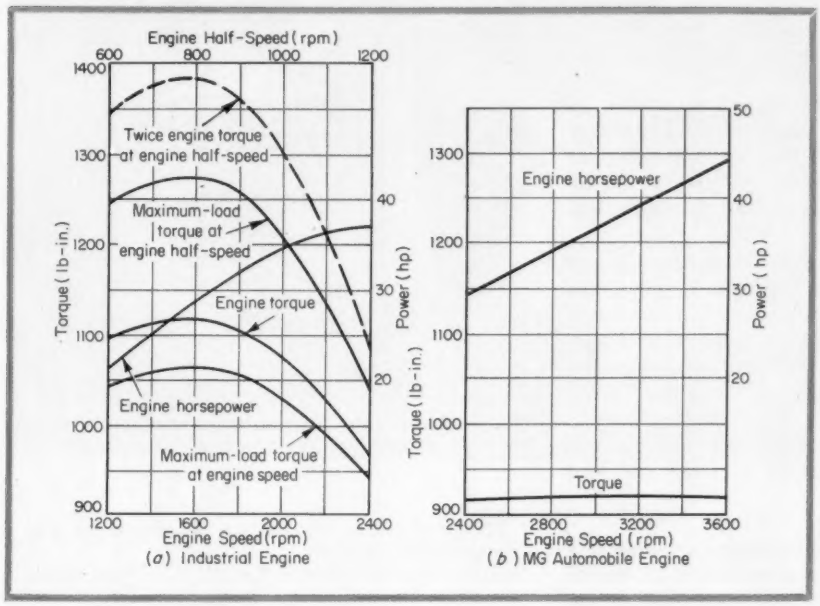
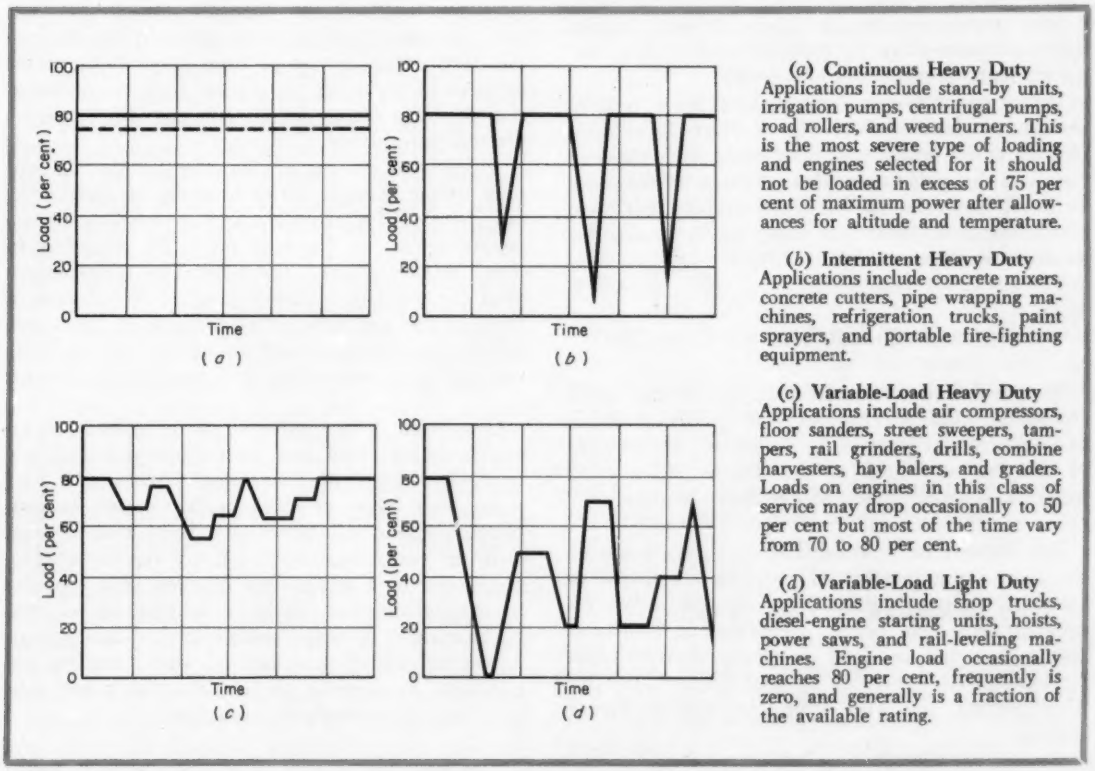



**Fig. 2 — Torque-speed curves of industrial engines usually exhibit characteristics quite different from those of automotive-type engines.**




**(a) Continuous Heavy Duty**
Applications include stand-by units, irrigation pumps, centrifugal pumps, road rollers, and weed burners. This is the most severe type of loading and engines selected for it should not be loaded in excess of 75 per cent of maximum power after allowances for altitude and temperature.

**(b) Intermittent Heavy Duty**
Applications include concrete mixers, concrete cutters, pipe wrapping machines, refrigeration trucks, paint sprayers, and portable fire-fighting equipment.

**(c) Variable-Load Heavy Duty**
Applications include air compressors, floor sanders, street sweepers, tampers, rail grinders, drills, combine harvesters, hay balers, and graders. Loads on engines in this class of service may drop occasionally to 50 per cent but most of the time vary from 70 to 80 per cent.

**(d) Variable-Load Light Duty**
Applications include shop trucks, diesel-engine starting units, hoists, power saws, and rail-leveling machines. Engine load occasionally reaches 80 per cent, frequently is zero, and generally is a fraction of the available rating.

**Fig. 3—Duty cycle is a reliable guide in selecting an engine for an untried type of service.**

low ambient temperatures without need for special attention.

**Torque Curves:** While horsepower is the primary basis governing engine selection, the shape of the torque curve is the key to engine selection when power at more than one speed is required. In automotive vehicles, a demand for increased torque to prevent stalling is met by the operator changing, or by automatically changing, gear ratios between engine and load. On the other hand, industrial applications seldom provide gear shifting; the engine must be designed to provide its own increase in torque to prevent stalling when subjected momentarily to load increase. Typical horsepower-speed and torque-speed curves for an automotive engine and an industrial engine of about the same size are shown in Fig. 2.

In particular, for machinery like hoists, concrete mixers, and hay balers, torque is more important than horsepower alone. High torque at the slower engine speeds is a must. Engine manufacturers normally supply torque curves. If not, torque curves can be plotted from the relationship, torque (lb-in.) = 63,000 (hp)/(rpm). To use a torque curve in engine selection, merely compare the engine torque curve and the torque required to move the load at the various speeds.

**Duty Cycle:** Another aid in engine selection is a plot of the probable duty cycle to which an engine will be subjected under normal conditions of operation. Fig. 3 associates four duty cycles with proved service applications. Long life and trouble-free performance can be expected from engines under comparable conditions of service.

When an engine is being chosen for a type of service not mentioned in Fig. 3, then direct comparison of its anticipated duty cycle with those of Fig. 3 is the guide to engine selection. Noteworthy is the 75 per cent limitation for engines that must run at constant speed and load, which is classified as continuous heavy duty.

## *Coupling Engine to Load*

Torque and speed requirements of the load when compared with the torques and speeds available from an engine frequently influence the method of coupling the load to the engine. All regular methods of coupling one to the other are used.

**Belt Drives:** Belts, either flat or V, are probably the most common ways of coupling an engine to the load. Belts are simple, low in cost, allow for misalignment, and permit differences in rotational speeds of engine and load. In conjunction with belt tighteners, belt drives can be used like a clutch for disconnecting the load from the engine during starting.

Among the objections to belt drives are:

1. Possibility of excessive bearing loads.

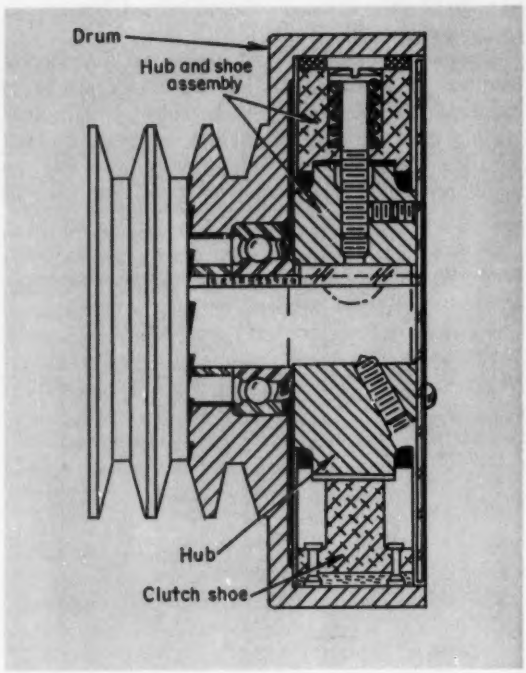



**Fig. 4—Clutch shoes in centrifugal clutch are displaced outward by centrifugal force to grip driven drum.**

2. In many cases, the necessity of starting the load along with the engine.
3. The need for distance between driver and driven pulleys (or sheaves) for adequate belt wrap.

Engine bearings are adequate for normal belt pull. Excessive bearing loads generally result from belt-declutching devices or from poor and unstable methods of mounting an engine. Careful consideration of these design details can pay off in engine life and performance.

A belt and pulleys are an effective way to amplify torque. Torque varies inversely as speed. The top curve of Fig. 2*a* illustrates a doubling of the engine torque at the load by a 2:1 reduction in speed between engine and load. The second curve from the top has ordinates that are 80 per cent of those of the top curve. Any ordinate of this curve defines the maximum load torque that can be safely used at the corresponding half speed of the engine.

**Couplings:** A conventional coupling between an engine and its load is a simple, compact, and economical method of connecting engine and load when both rotate at equal speeds. Variety in couplings is great. All types have been used satisfactorily in many applications. Every type is troublesome once in a while. One function of a coupling is to accommodate slight misalignments of two shafts without excessive bearing loads. Misalignment tolerances ordinarily associated with coupling applications for general purpose machinery are suitable for internal-combustion engines.

**Clutches:** Limitations of simple coupling methods have brought about the development of sev-

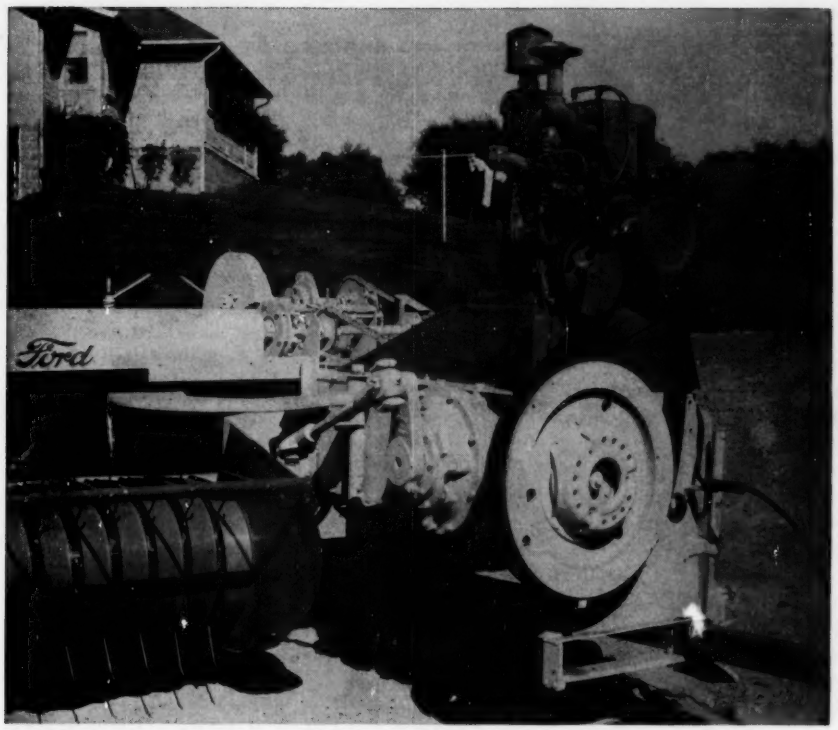



Fig. 5—Precleaner atop a two-cylinder baler-drive engine is located where air is least contaminated. Engine operates at two speeds: 1000 and 2800 rpm, developing 18 hp at maximum speed. V-belt drive provides a 6:1 speed reduction. Belt tightener serves as a declutching device during starting. (Photo, courtesy Ford Motor Co.)

eral types of clutches, three of which are: 1. Centrifugal clutch, Fig. 4. 2. Over-center clutch. 3. Automotive clutch.

At low engine speeds, a centrifugal clutch remains disengaged. As the engine speed increases, centrifugal force presses the shoes more firmly against the drum, slipping diminishes between the shoes and drum, the load is accelerated smoothly until the hub and drum rotate together. There is a difference of several hundred revolutions per minute between the free running speed and full engagement, depending upon the amount of power transmitted. Centrifugal clutches are made in a variety of sizes and are suitable for loads up to 25 hp.

Over-center clutches are most popular on equipment where the load may be coupled to the engine without regard to speed and where the engine may be disconnected from the load for relatively long periods of time. Many types of agricultural and industrial equipment use this type of clutch. Such clutches are bolted directly to the engine crankcase, using the crankshaft main bearing plate for centering. The output shaft is then concentric with the engine crankshaft, and loads are coupled to the engine-clutch combination in any desired manner.

Automotive clutches are mounted in the same manner as over-center clutches. They are not used regularly in industrial or agricultural equipment because the clutch must be held in the declutched position to disconnect the load. This type of clutch is used, however, on engines for tractors, shop trucks, and other self-propelled equipment where an operator is normally in attendance. On units where a high degree of slip is required between the engine and the load, automotive-type clutches provide an excellent coupling method.

**Gear and Chain Drives:** Speed-changing devices are on the market that use either gears or chains and sprockets. Such drives are quite compact, admit reversal in directions of rotation, and units having several ratios are available for use at the same center distance. Ratios commonly available are 2:1, 3:1, and 4:1 although other ratios, such as 6:1, are available in certain engine models.

Further, to facilitate the coupling of the load to the prime mover with reduction gears, these reduction units frequently have an over-center built-in clutch. They are called clutch-reduction gears.

**Torque Converters:** Torque converters are sometimes fitted to engines to achieve special combinations of speed and torque. Typical of this is a crane or shovel where high torque is required at low speed during load pick-up. Once the load is moving, the torque required levels off, and increased speed is desired. Such changes can be built into a torque converter, thereby eliminating the need to shift gears.

## *Electrical Equipment*

Manual starting by means of a crank or rope still predominates for engines under 40 hp. However, an ever-increasing percentage of these engines are being fitted with 6, 12, and 24-v electric starters. While the majority are fitted with 6-v starters, the switch by automobile manufacturers to 12

v units has had a marked influence also on industrial-engine electrical equipment. Starters of the 24-v type are used almost exclusively for military applications.

If an industrial engine is to be used where another electrical system is also needed to start a truck or tractor engine, economy in engine selection can be realized by purchasing the auxiliary engine fitted with an electric starter only. For example, electrical energy for starting and ignition can be furnished by the electrical system of the tractor which pulls a baler or trailer.

Under these conditions, it is necessary only to make sure that the auxiliary engine is fitted with a starter and ignition coil of the same voltage as the master electrical system. More often than not, the joint where a trailer is attached to a tractor provides a poor electrical connection because of grease, dirt, or some other semi-insulating material. A design tip is to insure good electrical connection by specifying a two-wire electrical hook-up.

Where full electrical equipment is to be supplied, care should be taken to evaluate fully the probable electrical load. Units which are started frequently during the day generally need larger generator outputs than engines which are started only infrequently. Generator output is a function of speed; hence, on slow-speed engines, the generator must be driven fast enough to supply minimum needs. Include in estimating electrical needs all lights, radios, and other electrical devices. Wise design practice is to consider any optional electrical equipment that might be added later.

## *Air Cleaners and Filters*

An engine breathes approximately 2 to 5 cu ft of air per minute. This intake is the greatest source for getting dirt into an engine. Among the devices to protect an engine at this vital point are: 1. Oil-wetted felt or mesh screens. 2. Dry-element air cleaners. 3. Oil-bath air cleaners. 4. Precleaners mounted on regular air cleaners, Fig. 5.

In general, air cleaners are sized for a specific displacement range. However, changes in firing order and specific operating conditions can affect the size of unit required to protect an engine adequately. The air cleaner supplied with an engine as original equipment represents a compromise based upon a wide range of environments and conditions under which engines operate. Optimum arrangements for air cleaning in a specific application can be made only when all data concerning expected operating conditions are known.

Oil-wetted mesh or felt screens, used sometimes on very small engines, are the simplest of all protective devices. Because of their size, the filtering media, and the lack of suitable means of keeping the filtering media wet, such filters have relatively short life. They are acceptable only for lightest duty.

Dry-element cleaners are widely used in automotive-type vehicles. In agricultural and industrial applications, they have had only limited success. While many factors are involved, one of the greatest is the formation of a mud-like coating when partially dirty cleaners are exposed overnight to dew or other moisture. Air cleaners on industrial and agricultural equipment are exposed to the elements; the same cleaners on automotive equipment are not. If suitable maintenance procedures could be anticipated, no doubt the high efficiency of dry-element cleaners would be beneficial. Field-test results and general experience indicate that adequate maintenance cannot be expected.

Oil-bath air cleaners currently present the best single-unit protection considering all the variables to which engines are subjected. If the oil cup is serviced in accordance with the engine manufacturer's recommendations, which may vary from application to application, a high degree of satisfaction is routine. For an oil-bath cleaner to work efficiently, it must be selected not only to suit engine displacement, but also to suit other conditions of operation, such as speed range and cylinder firing order.

The life and efficiency of any type of air cleaner can be improved upon by fitting it with a precleaner. A precleaner may be a simple screen, a plastic cup, a cylinder, or a dry-filter element. Each type contributes differently in assisting the air cleaner to supply filtered air to an engine.

The screen can be made up in many shapes, with or without a supporting sheet-metal body. It works quite adequately in keeping grass, weeds, or other fibrous debris from getting into the cleaner

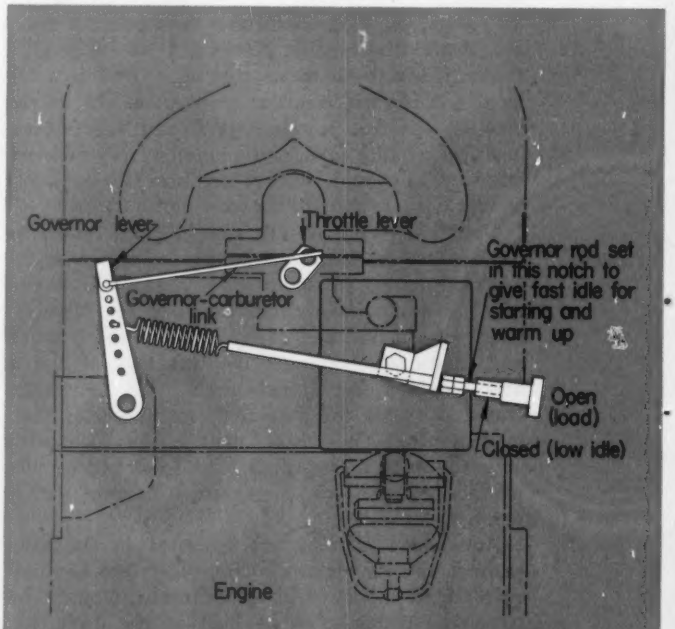



**Fig. 6—Speed-control mechanism provides closed position for low idling speed, intermediate position for fast idling during starting and warm up, and open position for running under load.**

proper, Fig. 5. It does not, however, help in keeping out dirt.

Plastic-cup precleaners are generally arranged with a perforated baffle which induces a swirling action to the incoming air. This action causes the heavier particles to be centrifuged out; hence, the air cleaner proper is required to handle only the fines. This results in lengthening the periods between air-cleaner service. Heavy particles are readily visible in plastic cleaners, and the operator is thereby warned as to the need for service.

Recently a variation of the plastic cup-type precleaner has appeared on the market in which a porous cylinder is used rather than a single cup. The larger surface plus a debris-gathering container affords a higher degree of air cleaning over longer periods between service.

## *Engine Speed Control*

Many agricultural and industrial engines operate at constant speed, which is maintained by a governor of the fly-ball type. Other engines may be set to operate at two specific speeds or more. Still others may be operated over the complete speed range of the engine.

For fixed-speed operation, a carburetor-governor linkage is most common. Either by changing tension on the governor lever with a range of springs, or by changing the lever-arm ratio with a specific spring, engine speed can be set so that the load speed is quite exact. Over-run speed—the difference between speeds with and without load—can be set to suit conditions of loading and accuracy desired. In general, an over-run speed of 150 to 200 rpm is used.

For certain types of operation three speeds are desired: 1. Idle. 2. Half throttle. 3. Full-load speed. This can be accomplished in several ways, but one of the most common is the linkage type, Fig. 6.

In other types of operation, the engine may be desired to operate at a fixed speed with occasional periods of running at idling speed. This is easily accomplished by a free lever and a spring-loaded carburetor in the linkage to the governor. Such an arrangement is frequently actuated by a solenoid, bellows, or other remotely controlled device.

Other common means of controlling speed include friction levers, ratchets, notched levers, and pull-out-and-half-twist-to-lock controls.

## *Engine Mounting*

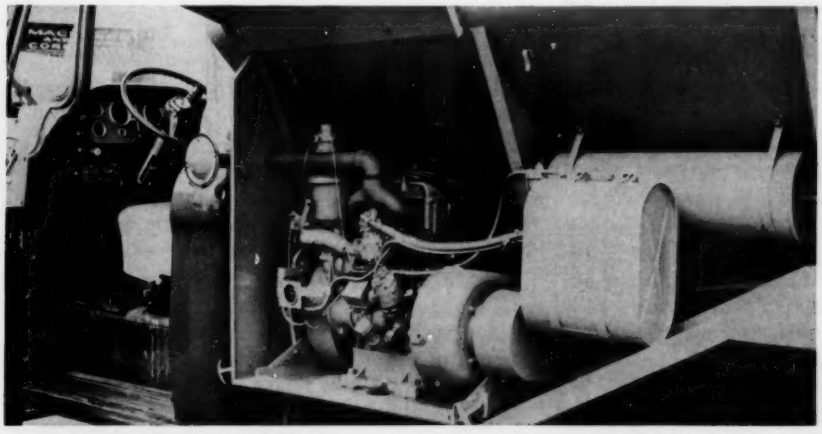
Where an engine is to be used and how it must be located with respect to the load usually influence, and sometimes govern, the selection of type of engine and the details of mounting it. Table 1 lists vertical, horizontal, and V-type engines. This designation pertains to the position of the cylinders relative to the crankshaft.

Most engines will stand 25 deg tilt from normal running position in any direction; many will stand greater tilt in one or more directions. Nevertheless, every engine has tilt positions beyond which its operation may be sporadic. Gas-tank location in relationship to carburetor, location of the oil pump, kinds of air cleaners, and governor control are conditions for study when an engine must operate at tilts greater than 25 deg—for example, in mowing on steep side hills. Special carburetors, remote oil pick-ups, other locations for fuel tanks, and/or the use of fuel pumps will solve most problems entailed by large tilt angles.

A flimsy foundation can easily permit misalignment, accentuate vibration, and cause engine failure in service. More complaints regarding excessive vibration are corrected by strengthening engine-mounting platforms than by any other method.

Vibration, while it may stem from the engine, can also be caused by: 1. Equipment having a ramming action, as in a baler. 2. Unmatched V-belt drives. 3. Reciprocating machinery, as piston pumps and compressors. 4. Machines having unbalanced rotating masses and unbalanced loading of any type.

In some instances, vibration mounts in conjunction with the redesign of the members of structural foundations for greater rigidity (not necessarily heavier) have been the solutions to vibration problems. In other cases, vibration problems have been solved by removing the mounts altogether and by bolting the engine solidly to the foundation structure. There is no one solution to vibration problems.



Variable-speed engine on highway spreader drives spreader mechanism and impeller vanes through a 2.67:1 gear reduction. Two-cylinder vertical engine develops 18 hp at 3200 rpm. An over-center clutch connects the engine and the spreader mechanism.

Better design of structure-type foundations for engines, however, would be definitely a step in the right direction. Engines are relatively heavy auxiliary units. Atop a vehicle, Fig. 5, is no doubt the best place for the engine for least exposure to dirt and debris. On the other hand, it is not the easiest place in which to provide an adequate engine foundation.

## *Protection Methods*

Foreign matter of any kind in an engine is detrimental. It can enter an engine via the cooling system, dirty fuel, and the crankcase breather either during normal operation or, more probably, through the use of unclean containers in transferring oil from supply to engine.

Engines must perform in all climates, under all kinds of weather conditions. Modern design concepts of exhaust mufflers, air cleaners, spark plugs, and magneto and distributor-wire outlets have tended to minimize problems formerly encountered due to rain. On engines with exposed spark plugs and wire outlets, rubber boots are available which form effective seals against almost every weather condition.

Manufacturers of air-cooled engines have been especially aggressive in studies and methods to keep foreign matter out of cooling systems. Where operating conditions are known to be quite dirty, the use of a rotating screen attached to the blower-flywheel provides a high degree of protection against debris entering the engine proper, Fig. 1. Airborne debris, which normally clings to a screen surface, is thrown off by centrifugal force.

In spite of such precautions, some foreign material may lodge in the cylinder fins and head fins. Heavy accumulations can block off cooling-air flow. If not promptly detected, the buildup could lead to piston bore scoring, and head and valve failures. To provide protection, high-temperature safety switches have been developed which will sense an abnormal temperature rise from these causes, from overloading, or from prolonged detonation. These switches shut an engine down by shorting out the magneto or by opening the primary circuit of a battery ignition unit.

As efficient as these devices are, there is no substitute for preventive maintenance. Air cleaners must be serviced at regular intervals, oil must be of the grade required and changed regularly, and cooling passages must be kept clean if satisfactory operation is to be expected.

## *Fuels and Lubricants*

No engine can operate without fuel to burn and a suitable lubricant. While gasoline in this country is by far the most popular fuel, many industrial engines can and do burn a variety of other fuels, such as natural gas, manufactured gas, diesel oil, fuel oil, alcohol, and liquid petroleum gas.

**Fuels:** Even gasoline comes in several grades, usually dependent upon octane number. To burn this multiplicity of fuels, engine compression ratio needs to be adjusted. The engine manufacturer makes these adjustments if notified about the fuel to be burned. This should be done because engines are regularly adjusted to burn gasoline, and many other fuels burned in them will not develop full power.

Of the fuels other than gasoline, liquid petroleum gas (LPG) is increasing in popularity. Unlike the other fuels, it may be used either in liquid or gaseous form, depending upon container size, amount of fuel an engine requires, and to some degree, the ambient temperatures encountered.

Container size and the temperature at which it is maintained limit engine size because of the small amount of gaseous fuel that rises by evaporation from the liquid surface within the container. Only the smaller engine sizes can be fueled by natural evaporation methods. If fuel is withdrawn from the container as a liquid, a much larger percentage of the fuel within the container is immediately available. However, liquid fuel must be converted to a gas before it can be burned, as with gasoline. This is accomplished by a vaporizer. Unlike the vaporization of gasoline, the vaporizer for LPG must be heated. Otherwise, the reduction in temperature as a consequence of the change of state from liquid to gaseous, soon freezes up the vaporizer and causes the engine to stop.

To realize the full potential of LPG as a fuel, it is customary to increase the compression ratio and to use faced valves and seats. If these things are not done, power loss on the order of 8 to 12 per cent may be expected. When set up specifically to burn LPG, 100 per cent of gasoline power may be realized. Moreover, some variation in power may be expected, depending upon the relative percentage of propane or butane in a given container, since all LPG fuel varies from lot to lot.

Occasional engines, primarily those for stand-by service on pumps, compressors, and generator sets, are set to burn either natural or manufactured gas. Such engines deliver approximately 80 per cent of rated power on fuel of 1000 Btu content and over. Such applications must be carefully evaluated, not only for Btu content of the fuel, but also because the type of gas to be burned may require modifications to lubricate the upper cylinder. In general, a 3 per cent power loss occurs for each 100 Btu under 1000. When fuels of low Btu content are used, easier starting is obtained with gasoline. The switch is made to gas after the engine warm up.

**Lubrication:** Although oil seldom wears out, it does become contaminated by natural engine blow-by, condensation of water in the crankcase, and by microscopic particles of iron from the normal wear of an engine. Engine wear can best be minimized by use of a proper lubricant changed regularly.

There are on the market now several types of multigrade oils designed primarily for automotive use. While such oils provide satisfactory lubrication for industrial engines, it is questionable whether their extra cost is justified under the usual operating conditions of an industrial type engine.

*Design curves for finding section properties of*

# TEES IN BENDING

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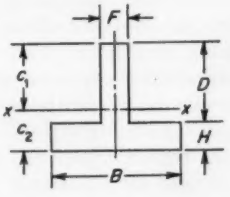
CALCULATING the properties of tee sections in bending is a tedious procedure by the usual methods. First the area of the cross section must be found, then the center of gravity, next the moment of inertia, and finally the section modulus. Calculating any one of these properties requires calculating those listed before it. Formulas have been suggested that avoid this difficulty. But these formulas depend on the difference of two numbers that are nearly equal and thus require very exact calculation for good results.

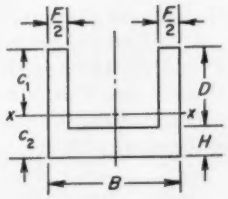
The formulas given here permit calculating any required property directly and accurately for beam sections with ribs on one side only and with a vertical center line, such as tees or channels bent at right angles to the flat side. The formulas should not be used for angles. Angles are weaker along a diagonal axis than they are along an axis parallel to the legs, and more complicated formulas are needed to calculate the stress. If angles are fastened together in symmetrical pairs they become equivalent to tees and channels. Otherwise they have to be heavier than tees or channels to carry the same load.

Each illustration with the Nomenclature represents the cross section of a beam loaded on the vertical center line. Neutral axis $x$-$x$ passes through

## Nomenclature

$A$ = Area, sq in.
$B$ = Width of base of section, in.
$c_1$ = Maximum fiber distance, in.
$c_2$ = Minimum fiber distance, in.
$D$ = Height of rib, in.
$E$ = Efficiency
$F$ = Thickness of rib, in.
$H$ = Thickness of base of section, in.
$I$ = Moment of inertia, in.$^4$
$K_1$ = Multiplier for calculating $Z_1$
$K_2$ = Multiplier for calculating $Z_2$
$K_3$ = Multiplier for calculating $I$
$M$ = Bending moment, lb-in.
$s_1$ = Bending stress in rib, psi $= M/Z_1$
$s_2$ = Bending stress in flat side, psi $= M/Z_2$
$T$ = $F/B$
$V$ = $D/H$
$Z_1$ = Minimum section modulus, in.$^3$ $= I/c_1$
$Z_2$ = Maximum section modulus, in.$^3$ $= I/c_2$




## Table 1—Section-Property Formulas

**Area (sq in.)**

$$A = BH(1 + TV)$$

**Maximum Fiber Distance (in.)**

$$c_1 = \frac{H}{2}\,\frac{1 + 2V + TV^2}{1 + TV}$$

**Minimum Fiber Distance (in.)**

$$c_2 = \frac{H}{2}\,\frac{1 + 2TV + TV^2}{1 + TV}$$

**Minimum Section Modulus (in.$^3$)**

$$Z_1 = \frac{BH^2}{6}\left[\frac{1 + 4TV + 6TV^2 + 4TV^3 + T^2V^4}{1 + 2V + TV^2}\right]$$

**Maximum Section Modulus (in.$^3$)**

$$Z_2 = \frac{BH^2}{6}\left[\frac{1 + 4TV + 6TV^2 + 4TV^3 + T^2V^4}{1 + 2TV + TV^2}\right]$$

**Moment of Inertia (in.$^4$)**

$$I = \frac{BH^3}{12}\left[\frac{1 + 4TV + 6TV^2 + 4TV^3 + T^2V^4}{1 + TV}\right]$$

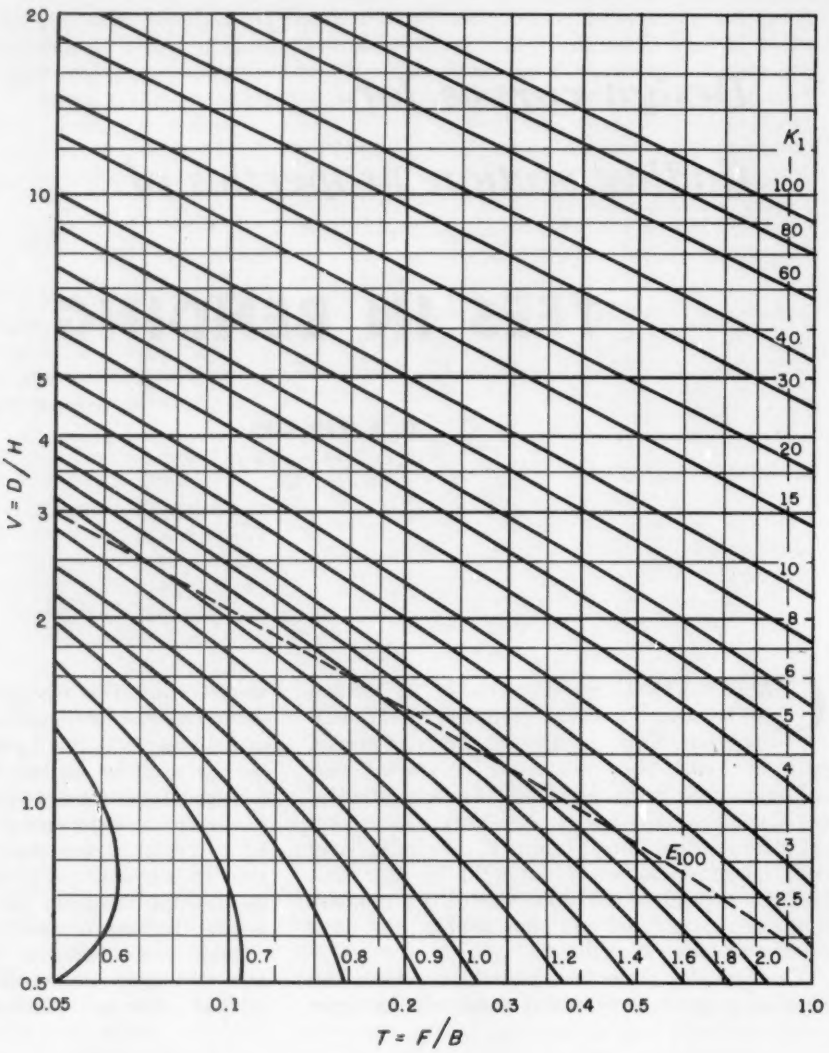



Fig. 1—Curves of $K_1$ for finding minimum section modulus: $Z_1 = (BH^2/6)K_1$.

the center of gravity of the section. Stresses due to bending are assumed to be proportional to the distance from neutral axis $x$-$x$. With beams that are symmetrical around $x$-$x$, such as rectangular or round bars and I beams, $x$-$x$ is at the middle of the height. Therefore, $c_1$ is equal to $c_2$, and stresses at the top and the bottom are equal. However, with beams that have ribs on one side only, such as tees and channels, $x$-$x$ is always closer to the flat side, $c_1$ is greater than $c_2$, and stress at the end of the rib is greater than stress in the flat side. The formula for the stress at the end of the rib is $s_1 = M/Z_1$.

Stress in the flat side is not important except with cast iron, which is weaker in tension than in compression. A tee or channel beam of cast iron is generally loaded with the flat side in tension. Then, stress at that point should be calculated from $s_2 = M/Z_2$. If the deflection of a beam is important, the moment of inertia will need to be determined. Handbook formulas will show how this is used to calculate deflection.

**Formulas:** By the method presented here, properties of tees and channels in bending depend on the ratios of the rib dimensions to the corresponding base plate dimensions. Term $T$ can be considered as rib thickness $F$ expressed as a fraction of base width $B$, and term $V$ can be considered as rib height $D$ expressed as a multiple of base thickness $H$. When there are two or more ribs, their combined thickness can be used for $F$. After $T = F/B$ and $V = D/H$ have been calculated, any required section property can be determined independently of the others with the formulas given in Table 1.

Each formula consists of an expression containing $B$ and $H$ which gives the corresponding property of the base. This is multiplied by a second expression containing $T$ and $V$ to determine the property of the entire section.

**Design Curves:** The curves given in Fig. 1, 2, and 3 can be used to evaluate the expressions in brackets —the $K$ factors—in the formulas for $Z_1$, $Z_2$, and $I$.

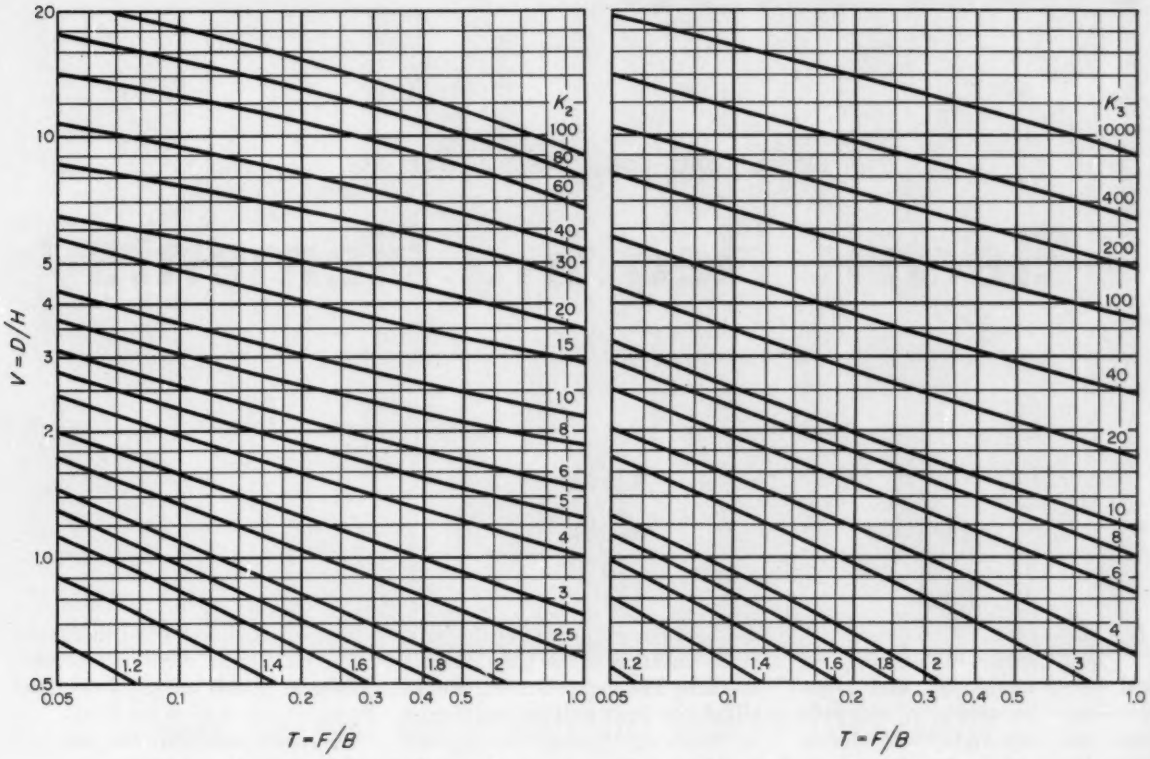



Fig. 2—Curves of $K_2$ for finding maximum section modulus: $Z_2 = (BH^2/6)K_2$.




Fig. 3—Curves of $K_3$ for finding moment of inertia: $I = (BH^3/12)K_3$.

Fig. 1 shows that $K_1$ can be less than one. This means that the minimum section modulus for the ribbed section is less than the section modulus of the base. The reason for this is that a small rib adds more, proportionately, to the distance $c_1$ than it does to moment of inertia $I$. These two are combined in minimum section modulus $Z_1$. Any section having $T$ and $V$ values that fall below curve $K_1 = 1.0$ in Fig. 1 will be weaker than the base.

The dotted curve in Fig. 1 marked $E_{100}$, for efficiency = 100 per cent, shows the lower limit of $T$ and $V$ values for most purposes. Any sections having $T$ and $V$ values below this curve will not be as strong as a simple rectangular section of width $B$ with thickness $H$ increased to give the same area as the ribbed section. For example, take the point where $T = 0.1$, $V = 2.0$ and $K_1 = 1.4$, which is just below the $E_{100}$ curve. The minimum section modulus will be

$$Z_1 = \frac{BH^2}{6} K_1 = \frac{BH^2}{6} \quad (1.4)$$

The area of this section will be

$$A = BH(1 + TV)$$
$$= BH[1 + 0.1(2)] = BH(1.2)$$

If $H$ in the rectangular base is multiplied by 1.2, the area will be the same as the ribbed section:

$$A = B[H(1.2)] = BH(1.2)$$

Section modulus of the rectangular section will be

$$Z = \frac{BH^2}{6} = \frac{B[H(1.2)]^2}{6}$$
$$= \frac{BH^2}{6} (1.44)$$

Thus the rectangular section with increased thickness has a larger section modulus than the ribbed section of the same area. The opposite will be true for $T$ and $V$ values above the curve for $E_{100}$.

Fig. 2 and 3 show that $K_2$ and $K_3$ are greater than one over the range of values covered. In fact, they will never be less than one. The smallest rib will increase the maximum section modulus and the moment of inertia over that of the base. When these properties control a design, sections having $T$ and $V$ values that would fall below the $E_{100}$ curve in Fig. 1 may be practical.

These formulas and curves for finding section properties of tees and channels in bending do not give any information about other factors that need to be considered to obtain a good design. The following rules are suggested:

1. Make $T$ not less than 0.1.
2. Make $V$ not more than 10.0.
3. Make $H$ not less than $F$.
4. Make $B$ not less than $D$.
5. Make $B$ not less than 1/15 of the length of the beam.

These rules of thumb are aimed at preventing designs that might fail by sidewise bending or buckling.

Design and application factors for

# Electric Heating Elements

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ALL of the various modes of heat transfer—conduction, free and forced convection, and radiation—may be active in removing heat from the surfaces of electric heating elements. An example is the tubular-type heating element in the modern electric range. This unit is fabricated by centering a helically wound section of resistance wire within the element sheath and then filling the space remaining inside the tube with an electrical insulating powder such as magnesium oxide. Finally, the tubes are swaged or rolled to reduce their diameter and to compress the powder. The heat generated within the resistance wire is transferred to the outer tubing by conduction through the insulating powder and, in addition, by radiation between particles. Heat is dissipated, in turn, from the outer tubing, or sheath, by radiation and free convection.

Other examples in this article represent applications in which one or more of the basic modes are dominant.

**Conduction:** In some cases, conduction is the principal heat-transfer mechanism removing heat from the outer sheath of heating elements. Low-temperature (750 F max) cartridge heaters are designed to fit snugly in a hole of a specified size and to dissipate their energy through the gas film in the space between the heater and the sides of the hole. Since radiation is not very effective at these low temperatures, almost all of the heat will be transferred by conduction through the gas film. If the size of the hole is increased so that the clearance is twice the design value, the temperature differential between the heater sheath and the surfaces of the hole will be approximately twice the design value. This increase in temperature differential may cause the temperature within the heater to rise beyond the maximum permissible.

**Natural Convection:** Immersion type heaters are designed to dissipate their heat to liquids by natural convection. Hence, any installation condition which inhibits the free circulation of the liquids over the heater element surfaces is to be avoided. Other installations to be avoided are those which place immersion type heaters close to the sides of the containing vessel or near the free surface of the liquid being heated.

Liquid physical properties — viscosity, thermal conductivity, specific heat, and density — are important factors in determining the surface coefficient of heat transfer for both forced and free convection. Thus, an immersion heater designed for heating water to a certain temperature may not be suitable for heating other liquids to this same temperature. Variations of 4-to-1 in the natural convection coefficient between different liquids are not uncommon.

**Forced Convection:** The principles of forced-convection heat transfer and fluid flow are used to heat gases flowing in ducts. When heaters are to be installed in ducts or boxes, configurations similar to heat exchangers are involved.

Flow information obtained from tests of heat-exchanger configurations can be directly applied whenever these same configurations occur in electric heating elements. Bypass effects in heat exchangers will also be present in electric heating applications. Spacings required to obtain good mixing between rows of heat exchanger tubes will also be required between rows of electric heating elements. Pressure drop through rows of electric heating elements may be calculated from correlations for the pressure drop in heat exchangers.

On the other hand, heat transfer data derived from heat exchanger studies *cannot* be used directly for determining electric heating element designs. The local surface heat-transfer coefficient varies along the circumference of a cylinder when flow is normal to its axis. This inherent variation in the local coefficient creates localized hot spots on the surface of cylindrical heating elements in cross flow. Heat-trans-


# How wood engineering helps this ship do the work of a fleet

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fer coefficients are *average* values taken over the entire surface of the tubes. For electric heating element design, coefficients based on hot-spot temperature must be used to determine the electric heater rating.

One additional consideration, not present in the design of heat exchangers, does exist in selecting and arranging electric elements for heating gases or any flowing fluid. When large temperature rises are required in the fluid, it may be necessary to derate or reduce the total power input to the heaters in the last few rows of the heater bank so that their temperatures do not exceed the maximum allowable.

**Radiation:** When temperatures in excess of 700 F are encountered in electric heating, heat transfer by radiation becomes important. The temperature level of operation is a prime factor in establishing the rate of heat transfer by radiation. Other factors include the geometry of the heating element, the geometry of the heat receiver, and their positions relative to each other and to any other surfaces. In addition to these geometric considerations, emissivity must be examined for all surfaces in the radiation system. The solution to problems involving radiation heat transfer can become quite complex when more than three surfaces are involved in the interchange.

**Materials:** Heating elements for high temperature service in ovens and furnaces are made from both metallic and nonmetallic electric resistance materials. Nonmetallic elements are primarily straight cylindrical shapes with low resistance sections at the ends where the elements pass through the furnace or oven walls. Metallic heating elements are frequently cast or formed in sinuous shapes.

In the design of metallic resistors, the spacing between adjacent loops must be made large enough to permit the heat generated within the material to radiate freely out into the furnace. The length of each loop is controlled by the ability of the material to support itself at high temperature.

Attention to the details of supporting the resistance heating elements in the furnace may reduce the operating temperature of the element considerably. When ceramic supports are employed, localized hot spots may develop because of the radiation screening or shading effect of the support and the inability of the ceramic material to conduct heat away from these local hot spots. Metallic hooks are preferred for supporting the elements, since they are usually much smaller than ceramic supports, and they can conduct the heat away from a hot spot more readily than ceramic materials.

With adequate support, the only limitation on the temperatures attained by electric heating elements is the melting point of the element material. However, since the oxidation rates at these elevated temperatures would normally result in a very short element life, protective or inert atmospheres are introduced into the furnace, or the furnace is designed for operation with a vacuum. Electric heat has an advantage over other methods of heating, in this case, since electric elements can operate in protective atmospheres without contaminating the atmosphere.

*AIEE Paper* No. 61-30, *"Heat Transfer Aspects of Electric Heating," presented at the AIEE Winter General Meeting, New York, Jan.-Feb.,* 1961, 9 *pp.*

# hydraulic

## Pulsation Damping Systems

*F. J. Wallace, senior lecturer, Dept. of Mechanical Engineering, Queen's University, Belfast, Northern Ireland.*

Pulsation problems inherent in installations comprising large and relatively slow-speed reciprocating compressors or engines. Free-piston gas generators are particularly sensitive to such pulsations. This paper is concerned with intake systems which usually consist of two distinct elements: Individual damping system for each gas generator, and a common ducting system for groups of gas generators.

Individual damping systems take the form of one or two large smoothing chambers or damping capacities connected by Venturi-shaped ducts. Individual damping systems must ensure that the magnitude of the pulsations reaching the common ducting system is sufficiently low to prevent damage to equipment and harm to people.

The object of analysis: 1. Put the design of such damping systems on a sound theoretical basis. 2. Facilitate the calculation of optimum dimensions and the form of the suction pulse of the gas generator.

*IME Paper No. 16/60, "Pulsation Damping Systems for Large Reciprocating Compressors and Free-Piston Gas Generators," accepted for publication after Feb. 28,* 1961, *24 pp.*

## Rotary Vane Pumps for High Speed and High Pressure

*R. P. Lambeck, engineering manager, Major Projects, and D. G. Snow, project supervisor, Aero Div., Vickers Inc.*

Design features and selection of materials which enable a vane pump to operate successfully with fluids having low viscosity, low lubricity, and large amounts of contamination. The pumps find increasing application in fuel systems where the main fuel pump must handle contaminant of the type specified in MIL-E-5007B.

The vane-pump design is the balanced or double-eccentric type. The pump has two inlet and two outlet port areas in opposing quadrants. All hydraulic forces are balanced so that there is no net load on the rotor bearings. This reduces the size of the bearings, holding overall size and weight to a minimum, and improves both pump life and efficiency. With the balanced design, the only loaded contact surfaces are the flat sides of the vanes against the rotor slots and the outer edge of the vanes against the cam ring.

*Paper No. L, "Aircraft Rotary Vane Pumps," presented at the 10th Annual Hydraulic Conference, at Vickers Inc., Detroit, Nov.* 1960, 4 *pp.*

## Aerodynamics in Centrifugal And Mixed-Flow Compressors

*F. Dallenbach, AirResearch Manufacturing Co. of Arizona*

Aerodynamic design criteria for controlling blade velocity distributions, deceleration ratios, and blade loading for centrifugal and mixed-flow impellers. Aerodynamic design criteria, including blade loading distributions for the impeller shroud

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Bristol, New Hampshire



P-2

and hub streamlines, are presented for a series of 12 impellers. This series is divided into three classes. The first class has backward-curved blades. The second class has straight, radial blades. The third class comprises mixed-flow impellers. Test results of all three classes show that, by adherence to recommended aerodynamic design practice, consistently high efficiencies are obtained. Other presentations include a generalized method for designing vaned diffusers, and a straight-line flow concept leading to optimum diffuser performance.

*SAE Paper No. 268A, "The Aerodynamic Design and Performance of Centrifugal and Mixed-Flow Compressors," presented at the 1961 SAE International Congress and Exposition of Automotive Engineering, Detroit, January, 1961, 23 pp.*

## materials

### Plastics in Seals For Extreme Environments

*Frank W. Tipton, George E. Trepus, and Robert S. Roper, Boeing Aircraft Co.*

Effects of high temperature, ionizing radiation, and cryogenic temperatures on the efficiency of elastomeric O-rings. As extreme conditions are imposed on these seals, there emerges an interdependency between elastomers and plastics in many seal designs.

In present systems, an O-ring and back-up ring-type seal is used whenever possible because of its simplicity, lightness, and low cost. But the applicability of this type of sealing in an extreme and relatively unexplored environment must be verified by physical and functional testing.

Results compare seals with and without back-up rings. As long as pressures remain low, either type of seal will work effectively. When high pressure is applied, the O-ring without a back-up ring is forced to one side of the groove, eventually resulting in extrusion into the clearance gap. Thus, an effective high-pressure seal must include both an elastomeric O-ring, which will conform to the sealing surface, and a rigid back-up ring, which furnishes the strength to resist ex-

trusion into the clearance gap.

*SPE Paper No. 26-1, "Utilization of Plastics in Seals for Extreme Environments," presented at the Seventeenth Annual Technical Conference of the Society of Plastics Engineers, Washington, D. C., Jan., 1961, 6 pp.*

## techniques

### Simpler Computer Programming

*Barrett Hargreaves, General Motors Research Laboratories*

Development of an automatic computer system — *GMR DYANA* — to reduce the time for programming. A digital computer can perform problem-solving tasks at blinding speed. But considerable time, mathematical skill, and computer training are required to prepare a problem in a suitable form for the computer. The *DYANA* language is problem-oriented and uses terms that resemble the engineer's language. Thus, the engineer can learn to set up many of his own problems for solution by the computer. *DYANA* is designed primarily for the study of any system whose mathematical model is known to be identical in structure and form to the model of a spring-mass-damper system.

*"GMR DYANA: The Computing System and its Applications," General Motors Engineering Journal, Vol. 8, No. 1, Jan.-Feb.-Mar., 1961, pp. 7 to 13.*

### Fatigue Strength of Forged Mild-Steel Shafts

*G. P. Smedley and B. K. Batten*

Results of torsional fatigue tests on forged mild-steel shafts 3 in. in diameter and having transverse holes of different diameters. It is shown that the theoretical stress-concentration factors for shafts having these notches, and loaded in torsion, may be considerably in excess of published values. The importance of radiusing the ends of oil holes to obtain improved fatigue strengths is indicated.

The influence of repairs by arc welding on the torsional fatigue strength of cast-steel test pieces is considered. Results of tests on pieces 3 in. in diameter show that fatigue strength can be at least equal to





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the value for forged steel shafts of the same tensile strength.

*"Fatigue Strength of Marine Shafting," presented at a general meeting of the North-East Coast Institution of Engineers and Shipbuilders, at Bolbec Hall, Newcastle upon Tyne, England, February, 1961, 27 pp.*

## processes

### Plastic Encapsulation for Microminiaturized Components

*C. R. Henderson, W. C. Earl and C. Kyratzis, CBS Laboratories*

Plastic encapsulation of nonlinear ferrites, and the effect of this encapsulation on the magnetic characteristics of the ferrites. This technique provides greater immunity to shock and vibration damage than conventional core frames. It also provides bit densities in excess of 1,000,000 per cubic foot. Chemical deposition and photographic techniques may be used to form a portion of the wiring matrix. Small evaluation memories have been fabricated using both toroids and transfluxors. Temperature tests on these memories show that encapsulation causes a slight increase in switching speed and a small decrease in output for a given drive current.

*IRE Paper No. 2, "Fabrication of Microminiaturized Core Memories by Plastic Encapsulation Techniques," presented in Session 1C, IRE Winter Convention on Military Electronics, Los Angeles, Feb., 1961.*

## management

### Planning a Central Data-Acquisition System

*E. J. Kovalcik, Senior Engineer, Instrumentation Group, Allison Div., General Motors Corp.*

Problems in planning a high-frequency low-signal-level central data-acquisition facility. Planners must understand that a central data-acquisition facility is a part of a data-handling system. Objectives of such a system may include decision making, problem solving, performance monitoring, process control, regulation, future planning, and, possibly, development of management controls. To obtain the an-

swers for the objectives, test programs will be requested which may entail recording almost any conceivable variable or parameter from all types of transducers to certain accuracies, as reliably as possible, and with a required fidelity.

*ISA Preprint No.* 12-SL-61, *"Design of a Central Data Acquisition System," presented at the Winter Instrument-Automation Conference and Exhibit, St. Louis, January,* 1961, 17 *pp.*

# mechanical

## Propulsion Applications Of Magnetohydrodynamics

*William McIlroy and A. E. Kunen, Plasma Propulsion Laboratory, Republic Aviation Corp.*

Problems associated with the operation of pulsed plasma accelerators, and the importance of specific impulse and energy conversion efficiency in the selection of a working engine. The accelerators are classified in terms of the manner in which the discharge takes place (direct or indirect) and also by their subsequent physical description (sheet or line). The development of the plasma pinch engine is presented as an example of an accelerator in the development stages.

The application of magnetohydrodynamics to electrical generation for ground and space installation is described briefly with its associated problems (principally concerning materials). A short description is given of the analytical work on the application of a magnetic field to a high-power thermionic converter to increase its efficiency.

*SAE Paper No.* 312B, *"MHD Applications for Space and Ground Power," presented at the* 1961 *SAE International Congress and Exposition of Automotive Engineering, Detroit, January,* 1961, 21 *pp.*

## Forging Press Drives

*H. Stern, and J. I. T. Green, both of Plant Engineering and Energy Div., British Iron and Steel Research Association, London, England.*

Extracts from trial results taken on presses with direct, steam-intensifier, and accumulator drives. Inherent features particular to each of these drives are distinguished from those common to all, or ap-





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plying to particular presses only. Of the three kinds of drive, the steam-intensifier drive is deemed obsolescent. Advantages and disadvantages of the other two drives are reviewed, with special reference to performance. It is concluded that full benefits of fast-acting presses can only be realized by parallel improvement in manipulation and the development of position control.

*IME Paper No. 27/60, "Performance of Forging Presses," presented at a meeting of the Institution of Mechanical Engineers, at the University, Sheffield, England, February,* 1961, 18 *pp.*

## electrical

### Flywheel Alternators With Ferromagnetic Wheels

*W. O. Henschke, R. E. Phelon Co.*

Application characteristics of permanent magnet alternators. The use of an electromagnetic field in an alternator permits the design of a constant voltage system with a simple relay or static type of controlling device, since over current and reverse current protections are inherent in the system. Prime factors in determining the voltage of an alternator at any instant are the load current, the rotational speed, and the field strength. The field strength may be varied by controlling the current that passes through the field winding. Thus a device that will measure the voltage of the alternator can be made to vary the field current to maintain a constant value of voltage as external conditions such as load and speed change.

Only one type of alternator is discussed in detail, but many other arrangements are feasible and have advantages for certain applications. The alternator system may be single or polyphase, may use a magnetic or a nonmagnetic enclosure, may have an electromagnetic or a permanent-magnet field, may be designed with both field and generating structures stationary or with one of these members moving. The advantages for small industrial and marine engine applications remain in favor of the alternator.

*SAE Paper No. 276C, "Flywheel Alter-*

*nators with Ferromagnetic Wheels," presented at the 1961 SAE International Congress and Exposition of Automotive Engineering, Detroit, January, 1961, 5 pp.*

## State of Battery Technology

*J. J. Lander, Delco-Remy Div., General Motors Corp.*

How far electrochemistry and battery technology have progressed in the utilization of the energy of materials. Observations are:

1. Battery technology has successfully utilized materials with theoretical energy yields up to about 300 whr/lb. When secondary battery technology is specified, this figure is only about 150 whr/lb.
2. There will be an approximate sort of relationship between the theoretical energy yields and the practical energy yields, so it is not to be expected that a given battery system can be stepped up appreciably in yield and compete out of its class.
3. To take advantage of reactants which provide energy above about 300 whr/lb, the use of fused-salt electrolytes will be the rule (hydrogen or hydrogen-producing substances are definitely excepted).
4. The highest energy yields are expected to be provided by fuel cells.

*SAE Paper No. 269E, "The General State of Advancement of Battery Technology," presented at the 1961 SAE International Congress and Exposition of Automotive Engineering, Detroit, January, 1961, 6 pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

*AIEE*—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

*General Motors Engineering Journal*, G. M. Technical Center, P. O. Box 177, North End Station, Detroit 2, Mich.

*IME*—The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London S.W. 1, England.

*IRE*—The Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

*ISA*—Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

*SAE*—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y., papers 50 cents to members, 75 cents to nonmembers.

*SPE*—Society of Plastics Engineers, Inc., 65 Prospect St., Stamford, Conn., papers 25 cents to members, 40 cents to nonmembers.





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# Helpful Literature
## for Design Engineers

**For copies of any literature listed, circle Item Number on Yellow Card—page 19**

### Adjustable-Speed Drives

Bulletin 2900 outlines an extensive line of adjustable-speed drives for applications in the ¾ to 2500-hp drive range. Four types of complete, packaged adjustable-speed drives are listed, and details on available ratings, speed ranges, type enclosures, associated controls, and standard and special modifications are included. 6 pages. Louis Allis Co., 427 E. Stewart St., Dept. P, Milwaukee 1, Wis.

*Circle 701 on Page 19*

### Structural Tubing

Technical Bulletin 12-3 provides engineering data on square, rectangular, and round steel tubing for structural applications in the construction of buildings, machinery, furniture, fixtures, appliances, truck bodies, racks, and supports. Advantages of structural tubing over other steel shapes are listed, and tolerance and fabricating data are included. 4 pages. Joseph T. Ryerson & Son Inc., Box 8000-A, Chicago 80, Ill.

*Circle 702 on Page 19*

### Air-Control Valves

Bulletin 60-2 presents in a single chart a full line of two, three, and four-way valves; also four-way, five-port, poppet-type units. Air and solenoid pilot operators are illustrated and co-ordinated in the chart with compatible valves. Cutaway drawings show construction features, sealing arrangements, poppets, and flow pattern through valves in normal position. 6 pages. Hoffman Valves Inc., 2360 W. Dorothy Lane, Dayton 39, Ohio.

*Circle 703 on Page 19*

### Magnetic Shields

Booklet of reference data on magnetic shields and shielding materials contains many helpful curves and tables for selecting the proper shield to suit the particular application. Catalog section of the booklet describes bezels for cathode-ray tubes, gear drives, shaft locks, bearings, couplings, knobs, dials, and dial locks. 16 pages. James Millen Mfg. Co. Inc., 150 Exchange St., Malden 48, Mass.

*Circle 704 on Page 19*

### Diallyl-Phthalate Varnishes

Technical Bulletin 32 provides information on the formulation and use of insulating varnishes based on Dapon diallyl-phthalate resins. Formula, application, and processing data, supported by photographs and tables, are given for Dapon varnishes. Cured resin properties of finished coatings are also described. 8 pages. Dapon Dept., Food Machinery & Chemical Corp., 161 E. 42nd St., New York 17, N. Y.

*Circle 705 on Page 19*

### Mercury Lamps

Booklet A-7264 provides latest information about initial and maintained lumen output, life ratings, and essential electrical and physical characteristics of company's mercury lamps. Booklet also describes lamp construction, ASA designations, color, and applications. 28 pages. Westinghouse Lamp Div., Westinghouse Electric Corp., MacArthur Avenue, Bloomfield, N. J.

*Circle 706 on Page 19*

### Timing Modules

Product Data Bulletin PD-1016 describes small, lightweight, microminiature timing modules. Publication contains dimensional drawings, table of characteristics, and complete specifications for types 406-1, 406-2, and 406-3, covering time delays from 0.1 to 60 sec. 5 pages. G-V Controls Inc., 101 Okner Parkway, Livingston, N. J.

*Circle 707 on Page 19*

### Self-Locking Fasteners

Aerospace Catalog 960 is a design manual which focuses attention on reduced-dimension, lightweight, self-locking fasteners. It covers complete lines of miniature hex, anchor, and clinch types useful in the assembly of units for avionic and electronic end use. Visual index of all standard types of stop nuts is included. 64 pages. Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.

*Circle 708 on Page 19*

### Welded-Diaphragm Bellows

New brochure presents extensive design and application data on welded-diaphragm bellows. Organized under eight section headings, brochure provides a concise account of welded-metal-diaphragm bellows design and applications. Pictures, dimensional drawings, tables, and curves are incorporated. 8 pages. Metal Bellows Corp., 3031 Mica Lane, Wellesley Hills 82, Mass.

*Circle 709 on Page 19*

### Quick-Disconnect Couplings

Quick reference to basic valving and connection principles of quick-disconnect couplings is available in Bulletin 254. Booklet summarizes advantages and limitations of specific valving and connection concepts. It also shows the variations or features possible with each concept. Basic methods of connecting the couplings are also described and illustrated. Types of remote disconnect couplings are explained, along with mounting methods. Brief case histories of four typical connection problems are presented. 8 pages. Aeroquip Corp., Jackson, Mich.

*Circle 710 on Page 19*

### Rod Ends, Bearings

Catalog 101 provides data on Alinabal rod ends and spherical bearings. All units are pictured, and dimensional drawings and tables provide dimensions. Materials used and load ratings are also included. Advantages of the units are pointed out. 12 pages. Split Ballbearing Div., MPB Inc., Lebanon, N. H.

*Circle 711 on Page 19*

### Rate, Acceleration Nomograph

New nomograph is useful for rate gyros and angular accelerometers. It makes possible rapid determination of rate in degrees per sec and acceleration in degrees per sec per sec when the frequency in cps and displacement in degrees are known. Micro Gee Products Inc., Dept. NOM, P. O. Box 1005, Culver City, Calif.

*Circle 712 on Page 19*

### Printed-Circuit Connectors

Form RTA-1260 provides data on several series of Continental right-angle pin and socket connectors for printed-circuit applications. Booklet contains pictures, tables, and dimensional drawings. Notes on materials used and on contact materials are included. 12 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

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### Graphite Products

"Design and Application Technics" is a new booklet to be published four times a year. Topics cover the development, design, production, and application of carbon-graphite parts, powder-metallurgy parts, graphite products, and electrical motor and generator brushes and contacts. First issue includes articles on high-temperature testing of Graphitar, application engineering applied to powder-metallurgy parts, and a new graphite lubricant for heavy industrial equipment. Subsequent issues will be sent. 6 pages. United States Graphite Co., Div., Wickes Corp., Saginaw, Mich.

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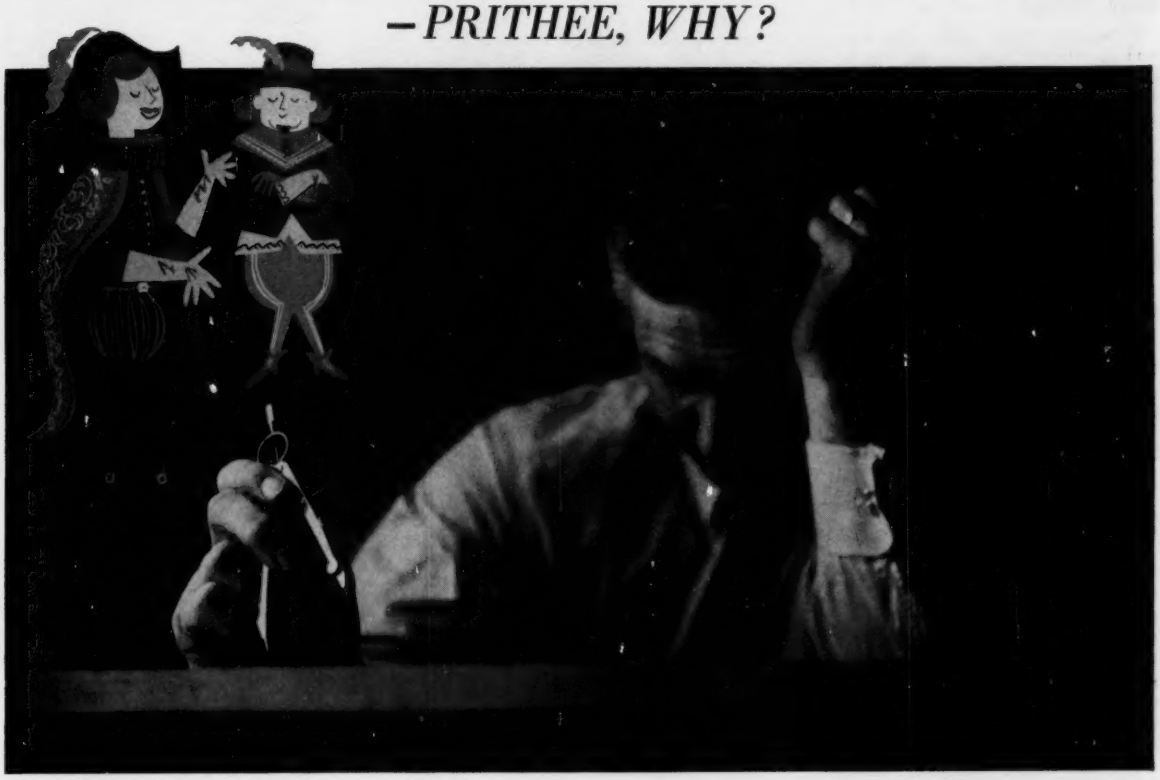
# YON DESIGN ENGINEER HATH A WOEBEGONE LOOK
## —*PRITHEE, WHY?*



**Ah, therein lies a most tragic tale. Yon design engineer hath created — out of his own imaginative genius, mind you — that miracle of miracles, that *summum bonum* —**

You mean —?

**Precisely. I mean a better chronodigitator.**

Come, come! If this engineer hath indeed created a better chronodigitator, why doth he not sing for sheer joy, why not click together his heels just for the—uh—heck of it? Why is he *woebegone?*

**'Tis a sad story.**

Out with it, man!

**Methinks his chronodigitator is too good to be true. He hath envisioned a super-chronodigitator which requires, alas, a multiple-program, adjustable cycling timer.**

**This super timer must be able to change program sequence and timing, *in minutes with standard parts*, even after installation. It must synchronize the operation of as many as twenty independent load circuits, with OFF-ON switch points field adjustable to factory standards! Yet, woe is he, its cost must not be out of this world. Now where, sire—?**

Where can he find such a timer? Ah-ha, and possibly ho-ho! At a manufactory yclept Cramer Controls Corporation in Connecticut.

They will provide him with their Type 540 timer in any of hundreds of different speeds to give timed actuations from the first second to the twelfth-night and beyond. Plus a neat little wench — er *wrench* — to change cam settings and a big vernier knob to assure precise operations — within one-half of one per cent of full cycle time — right in the field. Ha! Even the actuator is adjustable!

**What? I didst know this Cramer Controls Corporation as a most excellent company, unequalled for synchronous timing motors, miniature direct current motors and elapsed time indicators, but —**

But me no buts! Instead, fly to yon design engineer, tell him to be woebegone no more. At Cramer he will find control magicians! A research and development group after his own heart — creative, imaginative, ingenious!

**Forsooth!**

Tell him if he but write, a man from Cramer will be at his desk or drawing board forthwith! A man of great SAVVY (prithee pardon the expression) in precisely such problems as his.

**I fly!**

Wait! Tell him also to write for the data-filled bulletin PB-540. Posthaste!

**Zounds! You have helpt give birth to a new and better chronodigitator.**

What else?

**1 Cramer precision drive motor**
...high torque, truly synchronous operation, instant stop-start.

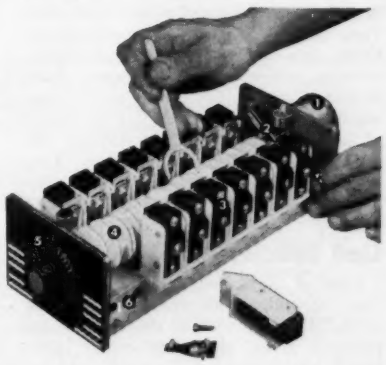
**2 Precision-hobbed gear linkage**
...inexpensive gear rack permits various speeds from same motor.

**3 SPDT load switches**
...from 3 to 20, rated 10 amps, in molded plastic shells each attached by one screw.

**4 Precision-cut cams**
...split design, easily adjustable from 2% to 98% of full rotation.

**5 Vernier dial**
...achieves field-setting accuracy of 0.5% of full cycle time.

**6 Extruded aluminum base**
...acts as conduit to protect all switch wiring.



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### Hose Fittings

New hose-fitting catalog covers fittings and assemblies that are detachable, reusable, and designed for medium and high-pressure industrial uses. Included are illustrated specification tables of several varieties of hose assemblies and fittings, adapters, and swivels. 8 pages. Lenz Co., 3301 Klepinger Rd., Dayton 1, Ohio.

Circle 715 on Page 19

### Aluminum Integral Motor

Publication P-86035-AU illustrates and describes recently announced aluminum integral motor. Included are specification and availability tables, as well as list of special construction features. Large photograph of the motor is incorporated to point out special features. 8 pages. Franklin Electric Co. Inc., 400 E. Spring St., Bluffton, Ind.

Circle 716 on Page 19

### Power-Transmission Equipment

Catalog 61-B provides data on variable-speed power-transmission equipment—pulleys, belts, sheaves, motor bases, countershaft bases, and Select-O-Speed transmissions. Large dimensional drawings and tables present ratings, dimensions, and representative applications. Formulas for use with the equipment are also provided. 34 pages. Lovejoy Flexible Coupling Co., 4945-4999 W. Lake St., Chicago 44, Ill.

Circle 717 on Page 19

### Hard Cemented Carbide

Profitable utilization of high rigidity in a material that has three times the stiffness of hardened steel is discussed in new pocket-sized booklet. Booklet gives typical examples in which use of the hard cemented carbide is particularly advantageous. It also notes the combination of other properties of the material, such as excellent wear resistance, high resistance to corrosion and abrasion, and dimensional stability. 16 pages. Kennametal Inc., Latrobe, Pa.

Circle 718 on Page 19

### Speed Reducers

Catalog P-61 includes data on single, compound, and double planetary speed reducers. Dimensional drawing and table provide size information on all units. Parts lists for each type are also given. Other data include tables of load characteristics, service factors, lubrication chart, AGMA Class 1 horsepower ratings, and maximum overhung load. Photographs of other products conclude the catalog. 18 pages. Philadelphia Gear Corp., King of Prussia, Pa.

Circle 719 on Page 19

### Limit Switches

Line of limit switches for automatic pilot control is described in Bulletin GEA-7312. Publication includes an application guide, short section on limit-switch terminology, and selection and installation guides. Bulletin discusses typical applications of the various switches, and photograph of each model is shown with call-outs. Diagrams give typical dimensions of each unit. 12 pages. General Electric Co., Schenectady 5, N. Y.

Circle 720 on Page 19

### Motor Starters

Bulletin 10-B1 pictures and describes manual starters for fractional-horse-power motors. Application and construction data are included, as well as information on enclosures. Dimensional drawings and lists of heater coils are also provided. 8 pages. Furnas Electric Co., Batavia, Ill.

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### Precision Wire

Two-color brochure describes the properties, characteristics, and possible application of Moleculoy wire, essentially a nonmagnetic, nickel-chromium alloy. Using illustrations, charts, and diagrams, bulletin provides data on temperature resistance, specific resistance, resistance and temperature coefficient tolerances, yield strength vs diameter for varying temperatures, and elongation vs diameter for varying temperatures. 8 pages. Molecu Wire Corp., Eatontown-Freehold Pike, Scobeyville, N. J.

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### Self-Locking Blind Nut

New solution to the problem of blind fastening is offered in a pocket-sized product bulletin covering the Davis press nut. Literature reviews the principle of operation of the one-piece, flush-mounting nut, suggests possible applications, and details general specification data. 6 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa.

Circle 723 on Page 19

### Vertical Motors

Integral-horsepower vertical motors are described in Bulletin 1485. Application information and mechanical features of the motors are stressed. Representative vertical motors are shown, and condensed dimension table is included. 2 pages. Century Electric Co., 18th & Pine Streets, St. Louis 3, Mo.

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### Door Interlock Switches

Data Sheet 186 covers eight standard door interlock switches used as safety devices on hazardous electronic equipment. Sheet includes three new series, and three series which have actuating rods constructed of high-strength thermoplastic. Photographs, mounting dimension drawings, mechanical characteristics, electrical ratings, and pricing information are included. 4 pages. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 725 on Page 19

### V-Belt Clutches

Complete line of standard and custom lever-action Ball-Lok clutches is described in Catalog 40. Emphasis is on the selection of the proper clutch to fit the particular application. General-purpose, heavy-duty, ball-bearing, and special-duty clutches are described. Optional shaft requirements, pulley sizes, and actuating devices are included, as well as price and application data. Several new clutch designs are also described. 16 pages. V-Belt Clutch Co., 418 N. Western Ave., Los Angeles 4, Calif.

Circle 726 on Page 19

### Oilless Bearings

Catalog 511 describes Arguto-MP self-lubricating, metal-plastic bearings combining high speed and load capacities. They operate in temperatures from −270 to +375 F without impairing lubrication properties. Catalog lists complete line of standard-size cylindrical and standard flange bearings. Tables of dimensional tolerances, recommended press fits, and other information is included. 12 pages. Arguto Oilless Bearing Co., 149 Berkley St., Philadelphia 44, Pa.

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### Silicone-Insulated Cable

"Single and Multiconductor Cable with Silicone Rubber" describes silicone-insulated power and lighting cable, hook-up wire, and ignition cable, as well as conductor cable for shipboard, missiles, and nuclear-power purposes. Curves and tables are included, in addition to a list of properties of the silicone rubber. 4 pages. Boston Insulated Wire & Cable Co., 63 Bay St., Boston 25, Mass.

Circle 728 on Page 19

### Stainless-Steel Clamps

Catalog Sheet PP-1160 describes two types and four series of Sure-Tite corrosion-resistant clamps for flexible plastic pipe. Pictures of the various types are shown, and dimensions and prices are given. 2 pages. Wittek Mfg. Co., 4305-43 W. 24th Place, Chicago 23, Ill.

Circle 729 on Page 19

### Centrifugal Pumps

Bulletin 3913 describes double-ball-bearing end-suction centrifugal pumps. Descriptions, photographs, performance tables, and dimension prints are all shown for sizes from 1 through 3 in. 4 pages. Deming Co., Salem, Ohio.

Circle 730 on Page 19

### Roller, Ball Bearings

Catalog 160 covers 24 standard types of tapered roller, cylindrical roller, journal roller, and ball radial bearings, as well as five types of ball and roller thrust bearings. Bearing type selection is simplified by a chart showing relative operating characteristics for each type of bearing. Many pages give charts, graphs, formulas, and examples for determining bearing life. Other information covers dimensions, mounting design, tolerances, and shaft and housing fit. Examples of special bearings are shown with their applications. 166 pages. Write on company letterhead to Dept. MD, Torrington Co., P. O. Box 118, Torrington, Conn.


## PAR Process thinking removed the IF ... saved 2 operations for DeVilbiss

DeVilbiss had good reason for wanting to replace machine screws as the means of fastening reed type intake valves in the popular TUFFY Paint Spray Compressor. Tapping was needed; an extra operation. Bulky screw heads required making recesses in an adjoining plate; another extra step. And, machine screws could be loosened by the vibrating valve.

Riveting would overcome all the problems, cut costs and increase assembly rate by 20 percent. BUT how could a sufficiently thin, flat rivet head be had, and at reasonable cost?

An ingenious answer came from the TRS man applying his PAR Process approach to the problem. *"We'll design special jaws and a driver, and work out the feeding details so that you can feed standard oval head rivets and flatten them in the setting operation."*

It was successful! From the simplified process, DeVilbiss gets a neat saving, faster assembly and stronger fastenings that are better sealed against leakage. And, of course, rivets cost less to buy.

**FIND OUT what the PAR Process can save you**

The PAR Process starts with a search by your TRS man for ways to eliminate or simplify and speed up steps in assembly. It is made effective by specially organized TRS procedures, backed by unique TRS developments in rivets and riveting machines.

The PAR Process may bring you better integration and greater automation of assembly operations, or even a cost-cutting change in basic assembly method. Ask for a check of your operations . . . it can be worth dollars to you.

*Don't Buy Riveting Machines until you learn how the TRS* **PAR** *process revolutionizes riveting*

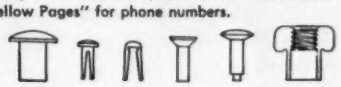
**TRS®**

**TUBULAR RIVET & STUD COMPANY**

QUINCY 70, MASSACHUSETTS • TRS SALES OFFICES: Atlanta • Buffalo • Charlotte • Chicago Cleveland • Dallas • Detroit • Hartford • Indianapolis • Los Angeles • New York Philadelphia • Pittsfield • Quincy • St. Louis • Seattle. WAREHOUSE IN CHICAGO

See "Yellow Pages" for phone numbers.

*If it's a Tubular Rivet TRS makes it . . . and Better*



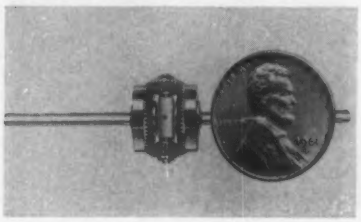
# New Parts and Materials

**Use Yellow Card, page 19, to obtain more information**

## *Precision Differentials*

**miniature units have backlash of 8 min or less**

Subminiature precision differentials, available for critical applications in computer assemblies and control instruments, are two-spider-gear units with ½-in. diam swing (clearance circle) to permit extreme miniaturization. Made entirely of stainless steel, each differential employs six miniature ball bearings which conform to ABEC 7 tolerance require-



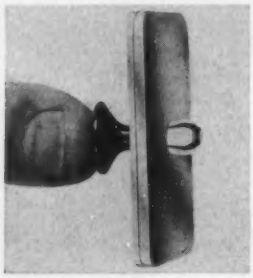
ments. Backlash is held to 8 min or less and breakaway torque to 0.02 oz-in.; balance is maintained at all times. Differentials are available with either 0.0779 or 0.0935-in. diam shafts with over-all lengths to 3 in. Pitch and number of teeth on end gears can be selected from a wide range. End gears are made from flat blanks that are parallel within 0.0002 in. **Instru-Lec Corp.**, 520 Homestead Ave., Mt. Vernon, N. Y.

*Circle 731 on Page 19*

## *Plunger-Type Fastener*

**for panels, doors, drawers, and other sections**

Nylatch plunger-type fastener consists of a molded plastic grommet and plunger, both of which remain captive in a removable panel, door, or other section. Grommet is placed into a standard drilled hole and plunger is inserted within the grommet. To fasten, assembly in fixed panel is placed against panel that it is to be connected to. As the



holes line up, pressure on the plunger expands fingers of grommet through the hole, making grommet on the inside a greater diameter than the hole itself. Retracting the plunger collapses fingers, permitting unit to be removed. Only two holes with standard tolerances are required for installation. Grommet floats for misalignment of holes. Single-size unit accommodates a wide range of thicknesses. **Hartwell Corp.**, 9035 Venice Blvd., Los Angeles 34, Calif.

*Circle 732 on Page 19*

## *Miniature Valve*

**in brass and Type 316 stainless steel**

Miniature Series-0 valve, equipped with Swagelok tube-fitting connections for ⅛-in. OD tubing, is available in brass and Type 316 stainless steel. Straight-pattern, forged-body valve is only 2¼ in. high. Straight and angle-pattern valves are also available with ⅛-in. male pipe ends. Pressure rating is 3000

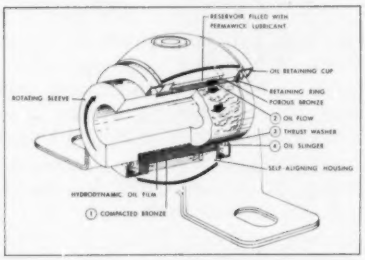
psi at room temperature, and orifice size is 0.080 in. **Whitey Research Tool Co.**, 5525 Marshall St., Oakland 8, Calif.

*Circle 733 on Page 19*

## *Sleeve Pillow Block*

**quiet unit operates on hydrodynamic oil film**

New sleeve pillow block handles loads of 50 psi at speeds of 1750 rpm and more, and handles moderate thrust loads. Self-aligning bearing operates with unground shafting since inner and outer races are integral parts of the assembly. Unit has a lifetime recirculatory oiling system, resists moisture and dust, and will not leak oil. By eliminating metal-to-metal contact between rotating inner sleeve and stationary bushing, oil film minimizes friction, heat buildup, and vibration. Self-metering oiling system uses Permawick lubricant. Block is available in




½, ⅝, and ¾-in. bores in strap or flange-mounting models. **Congress Drives Div., Tann Corp.**, 3750 E. Outer Drive, Detroit 34, Mich.

*Circle 734 on Page 19*

## *Printed-Board Connector*

**produces direct contact without solder**

Pos-E-Kon unit connects flat conductor cable to printed-circuit boards or to flexible etched circuitry. It produces a direct conductor-to-

***for***

- ***small sheave diameters***
- ***short centers • high speeds***
- ***quiet, vibrationless operation***

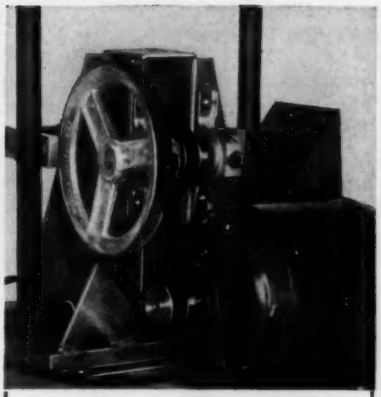
# New R/M CX* MOLDED V-Belts Outlast Others 8 to 1!

Other notched belts are cut at the sides . . . leave components exposed to atmosphere and permit separation, costly wear on sheave grooves. CX V-Belt is the *only* fully *molded* . . . fully *jacketed* notched V-belt. This exclusive R/M development provides drive design and performance advantages not possible with conventional belts.

- **No Cut Notches—No Exposed Sides—No Separation**
- **Quieter, Smoother, Cooler Running**
- **High Flexibility—Resists Flex-Cracking**
- **Holds Shape and Effective Length**
- **Micro-positioned Power Arch Strength Member**
- **Vibrationless—No Slap, No Hum, No Buzz**
- **Longer Drive Life**

Talk to R/M transmission specialists about new CX V-belts or other R/M belts for *every* drive application.

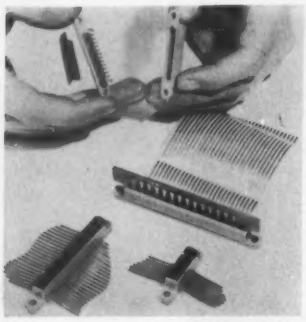
*Patented, made for original equipment



**The only fully molded, fully jacketed, notched V-belt made. Available in many sizes for a wide range of design requirements. Write for Bulletin M220.**

RM141

**RAYBESTOS-MANHATTAN, INC.**
**MANHATTAN RUBBER DIVISION • PASSAIC, N. J.**
*ENGINEERED RUBBER PRODUCTS*



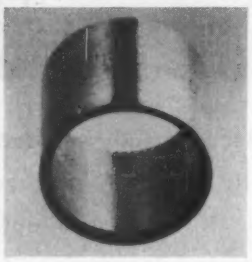
conductor contact without solder. Continuous one-piece spring locks cable into connector and provides a pressure point at each conductor contact. Connector permits the removal of both cable and printed boards at any time. **Thomas & Betts Co.**, 36 Butler St., Elizabeth, N. J.

*Circle 735 on Page 19*

## Stainless-Steel Bushings

**have reinforced Teflon inserts**

Stainless-steel bushings, designated Fluor-O-Bearings, have reinforced Teflon inserts permanently bonded to the inside diameter. Bushings are particularly suitable to applications involving liquid oxygen or other exotic fluids. Glass cloth is encapsulated in the Teflon to increase wear characteristics and virtually eliminate cold flow. **Fluorocarbon Co.**, 1754 S. Clementine, Anaheim, Calif.



*Circle 736 on Page 19*

## Gasket Compound

**for temperatures from −65 to +400 F**

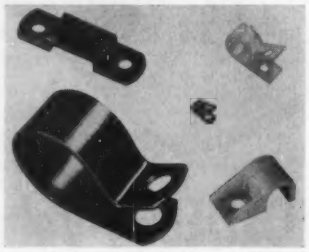
Seal-Last gasket compound for leakproofing gasketed assemblies also can be used to repair broken gaskets, to build up damaged, misaligned, or warped flanged surfaces, or as a gasket substitute where surfaces permit. Compound may be used with water, steam, oil or water-based hydraulic fluids, L-P and natural gases, petroleum products, mild corrosives, and many chemicals. Temperature range is −65 to +400 F, with pressures to 5000 psi. Soft-set variety is for connections that must be disassembled periodically, and hard-set type is for permanent installations. Both types are furnished in 1½, 3, and 11-oz tubes. **Crane Packing Co., Dept. MD-1**, 6400 Oakton St., Morton Grove, Ill.

*Circle 737 on Page 19*

## Nylon Cable Clamps

**for −60 to +275 F service when subjected to load**

New sizes of nylon cable clamps cover applications from subminiature to 1¾-in. size. In addition, new types and sizes of clamps for special fastening applications are available, including flat clamps, molded half-clips, and snap clips. Clamps are available for service between −60 and +275 F when subjected to load. Material is unaffected by petroleum oils and greases at temperatures to 300 F. **Weckesser Co. Inc., Dept. MD-1**, 5701 Northwest Highway, Chicago 46, Ill.



*Circle 738 on Page 19*

## Pin Terminals

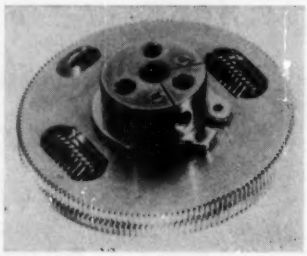
**for any 0.040-in. socket**

Two printed-circuit pin terminals, designated No. 2970 and 2971, are designed for any 0.040-in socket, such as a miniature tube socket. Part 2970 has a pin length of 0.300 in. and No. 2971 a length of 0.150 in. Both terminals have three staking shank lengths of 0.051, 0.082, and 0.113 in. Terminals can be used for staking to boards which are later encapsulated. Pins are brass, finished with hard gold over silver plate. **Cambridge Thermionic Corp.**, 45 Concord Ave., Cambridge 38, Mass.

*Circle 739 on Page 19*

## Antibacklash Gear

**two-piece unit is spring-loaded**



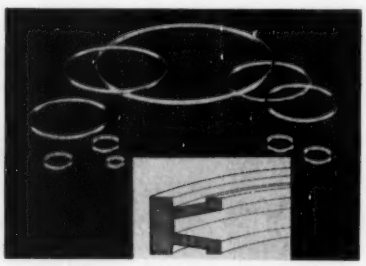
Improved antibacklash gear, for use wherever extreme precision is required, is available in varieties of stainless steel. The two-piece gear is spring-loaded to eliminate backlash in the mechanism. Two teeth are offset to insure a controlled antibacklash pressure. Diameter and concentricities are held to 0.0002-in. tolerances, and gear conforms to AGMA Precision Class 3. Diametral pitch is 96 or 120. **Roi Gears Inc.**, 2670 E. Walnut St., Pasadena, Calif.

*Circle 740 on Page 19*

## Metallic Static Face Seals

**for temperatures from −450 to +2000 F**

Series HS metallic static face seals provide zero leakage at temperatures from −450 to +2000 F and pressures to 20,000 psi. Seals are available in a wide range of materials, most with platings of silver, gold, indium, Teflon, Kel-F, and copper. Seals are lapped to provide flatness and smoothness of the sealing faces. A flat surface with a finish of 32 rms or better is adequate to provide a mating surface. Seals incorporate an integral spacer. Installation is accomplished by in-



**Are motor specs** straight-jacketing your product designs? Here's handy help from J&H that may show you ways your products can be made *more* squat, thin, quiet, cool, tough or submersible—at moderate cost even in moderate quantities. It shows how J&H motor elements and characteristics can be tailored to your product envelope. And it gives you a guide to relative costs for each type of modification, and the minimum practical production quantities for each.

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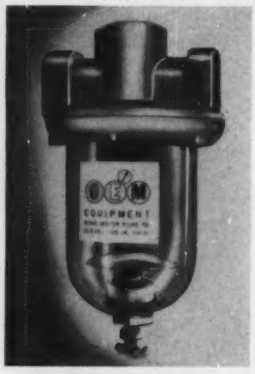
dexing the seal to one mating surface and bringing the opposing surface against the seal. Seals are reusable, lightweight, and are furnished in a wide range of sizes. **Haskel Seals Div., Haskel Engineering & Supply Co.**, 1236 S. Central Ave., Glendale 4, Calif.

*Circle 741 on Page 19*

## *Air Filter*

**has high-strength Monel screens**

Mark MDF Quarter Turn manual-drain air filter can be cleaned in the line without shutting off the air or removing the bowl. Centrifugal



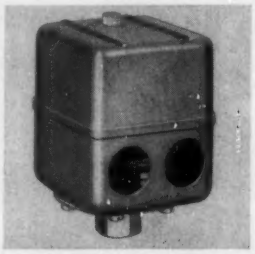

action spins out solids and moisture, throwing them to the bottom of the bowl. There is no perceptible pressure drop through high strength Monel screens. Contaminants are manually drained. Unit is available in 1/4, 3/8, and 1/2-in. full-area pipe sizes. **OEM Equipment**, 19560 Center Ridge Rd., Cleveland 16, Ohio.

*Circle 742 on Page 19*

## *Pressure Switch*

**for water systems and air compressors**

Rated 1½ hp, 150 psi maximum, new pressure switch for water systems and air compressors is available in two enclosure styles. Features include pressure-wire connectors, visible fine-silver contacts, no-drift pressure settings, snap action, optional pulsation orifice, and optional hand disconnect. Switches are available with contacts which close at the low-pressure setting,



close at the high-pressure setting, or with one normally open and one normally closed contact. All parts are either corrosion resistant or have been treated to resist corrosion. **Furnas Electric Co.**, 1045 McKee St., Batavia, Ill.

*Circle 743 on Page 19*

### *Flame Retardant*

**for rigid polyether foams**

Niax Flame Retardant A, adds flame-retardant properties to rigid polyether (urethane) foams. Material is a free-flowing powder that is dispersed in the resin side of the foam formulation. Components of the foam formulations are then processed in the usual manner. Greatest effectiveness for the retardant is achieved in rigid polyether-foam systems, though it can be used to advantage in most rigid foam formulations. Material makes only minor changes in the properties of foams prepared from a given formulation. Compressive and tensile strengths at room temperature are lowered somewhat, depending on amount of flame retardant used. Compressive strength at elevated temperatures is not affected, and dimensional stability under humid aging conditions is improved. Flame retardant is available in 10 and 41-gal containers holding 30 and 140 lb, respectively. **Union Carbide Chemicals Co., Div., Union Carbide Corp.**, 270 Park Ave., New York 17, N. Y.

*Circle 744 on Page 19*

### *Rapid-Reversing Motors*

**for high-production machine-tool uses**

Rapid-reversing motors are available in a complete line of integral-horsepower, polyphase ratings in open drip-proof, totally enclosed fan-cooled, and nonventilated enclosures. They are also available



*Circle 480 on Page 19*

For high strength without excessive weight, the designer of this heavy truck chose Tenzaloy for the front engine supporting frame.

# *Why TENZALOY is the most widely used high-strength aluminum casting alloy*

Among high-strength, self-aging aluminum casting alloys, Tenzaloy has won greatest acceptance and widest use by designers because of its unique all-round combination of properties. Outstanding among these special qualities are:

- High yield and tensile strength, combined with adequate ductility
- Exceptional machinability
- Remarkable dimensional stability
- High impact, shock resistance

When Tenzaloy is specified, one big problem is eliminated: heat treatment. Without any artificial thermal treatment, Tenzaloy castings will precipitation-harden at room temperature to give properties normally obtainable only by the expensive solution treating, quenching, and artificial aging of the heat-treatable alloys.

*Here are typical properties for Federated Tenzaloy:*

| | |
|---|---|
| Tensile strength | 35,000 psi |
| Yield strength | 25,000 psi |
| Elongation (in 2 in.) | 4-5% |
| Brinell hardness No. | 74 |
| Impact strength (Charpy in ft.-lbs.): | |
| Notched | 3 |
| Un-notched | 14 |
| Electrical conductivity | 35% |

Tenzaloy also is corrosion resistant, has superior ductility, and is easily anodized, dyed and polished to brilliant decorative finishes. Castability is excellent in green sand, plaster, investment, shell, oil-bonded sand and precision molds of all kinds. No special techniques are required for handling Tenzaloy in the foundry. Since Tenzaloy has mechanical properties equivalent to such common heat-treated alloys as 195T6, 355T6, 356T6 and 319T6, it can be substituted in applications where any of these heat-treated alloys are presently used.

It is particularly suited to high-strength designs where load carrying capacity and impact strength are essential. For example: frames, brackets, levers, bases, housings, missile ground handling equipment, jet aircraft turntables, explosion-proof enclosures, heavy-duty wheel hubs and cable drums, to name a representative few.

Tenzaloy can widen your design possibilities, increase production efficiency, improve your products, reduce costs. Get complete facts on its physical and mechanical properties by writing for Bulletin No. 103 R5 to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

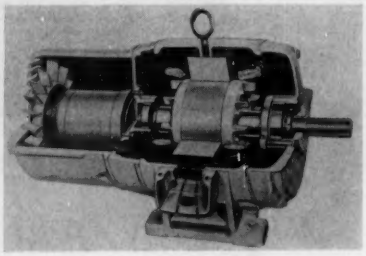
TENZALOY

FEDERATED METALS DIVISION **ASARCO**

*American Smelting and Refining Company*
*120 Broadway, New York 5, N. Y.*

Circle 481 on Page 19

in blower-cooled constructions to supply a continuous unidirectional supply of air for maximum cooling and reversing capacity. Units are designed for high-production machine-tool applications, providing up to 125 idle reversals per min in



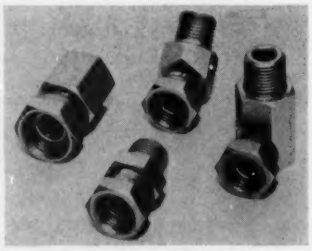
the smaller sizes with open-type construction and over 200 idle reversals per min with blower-cooled designs. **Louis Allis Co.**, 427 E. Stewart St., Milwaukee, 1, Wis.

*Circle 745 on Page 19*

## Pipe and Hose Fittings

**in four pipe sizes to 1 in.**

Pipe and hose fittings have a swiveling nut which permits connection to components without being turned or twisted. Captive nut, swiveling on this fitting, is turned to draw pipe or hose end against chamfered seat on fitting, effecting a high-pressure seal. Of brazed-steel construction, fittings are available in four common straight and



angle styles in sizes up to 1-in. pipe size. **L & L Mfg. Co.**, 21590 Hoover Rd., Warren, Mich.

*Circle 746 on Page 19*

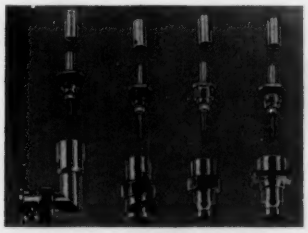
## Coaxial Cable Connectors

**have only three handling parts**

Coaxial cable connectors with crimp-on construction are available in many styles. Connectors, both in miniature and bayonet-locking



*Circle 482 on Page 19*



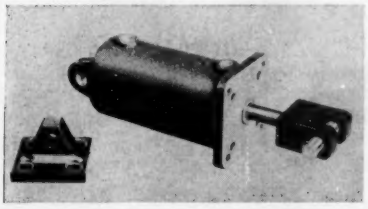
series, have only three handling parts to afford convenience in assembly, inspection, and replacement of damaged connector bodies. Available in weatherproof or nonweatherproof units, connectors have captive contact construction and minimum 50-lb cable pull. **Dage Electric Co. Inc.**, 67 N. Second St., Beech Grove, Ind.

*Circle 747 on Page 19*

### *Single-Acting Cylinder*

**with face or clevis mount**

Spring-return, single-acting pneumatic cylinder uses slightly more than half the air volume required by double-acting cylinders of the same size, and can be used as a double-acting cylinder when needed. Air-clamp cylinder, with face or clevis mounts, is available in 2¼, 3, 4, and 5-in. bore sizes with 1, 2, or 3-in. strokes. Simplified return action allows the use of a three-way valve and results in simplified piping. **Fluid Dynamics Div., Mead Specialties Co.**, 4114 N. Knox Ave., Chicago 41, Ill.



*Circle 748 on Page 19*

### *Pneumatic Valve*

**operates on pressures to 150 psi**

Model I-J-4 is a fast-acting, ⅛-in., four-way pneumatic valve, single-solenoid operated, which works with less than 10 psi in the line. Valve has an aluminum body and poppet-type piston of Buna-N


## . . . a line of industry-wide favorites, built to make tough applications seem easy

When it comes to building electric motor-powered equipment, *make sure of your horsepower source.* Before you specify any motor brand, consult with your A. O. Smith Motor Man. He'll show you how the horses of A. O. Smith (a full line of integrals and fractionals both polyphase and single-phase) help users surmount application barriers.

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**Tipp City, Ohio**

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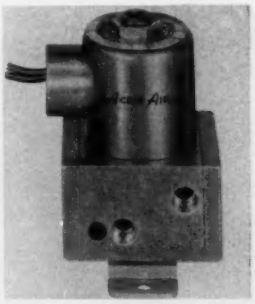
Milwaukee 1, Wisconsin, U. S. A.



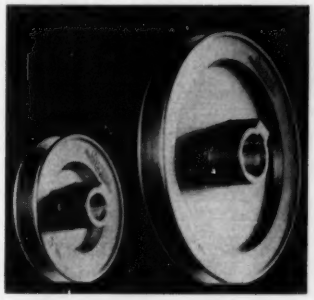
bonded to stainless steel. There are no springs in the main body, permitting full-line air flow in a 3½-in. high, 2 5/-16-in. square unit. All parts are noncorrosive. Valve can be repaired without removal from line. Model I-J-4 operates on pressures to 150 psi. **Acro Air Associates,** 16736 Foothill Blvd., San Leandro, Calif.

*Circle 749 on Page 19*

### *Driver Pulleys*

**are 20 per cent stronger than previous models**

Increased strength in new driver pulleys is the result of redistribution of metal to provide heavier cross-sections in the critical area where the pulley flanges merge. Pulleys are available in ½, ⅝, ¾, and 1-in. bores with standard key-



way, in pulley diameters from 1½ to 16 in. **Congress Drives Div., Tann Corp.,** 3750 E. Outer Drive, Detroit 34, Mich.

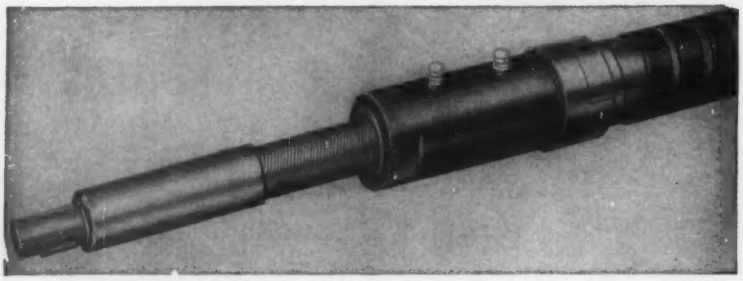
*Circle 750 on Page 19*

### *Synthetic Fiber*

**cuts without fraying or raveling**

Fiberloc, manufactured of synthetic fibers, is bonded by a technique that eliminates the normal felting process. Material is stronger and

# HOW TO SELECT FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS



1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing.

For Power Drive applications, the following factors must be considered.

**1. Torque (lb. in.)** to be transmitted. (The starting torque should be used in making selections.)

**2. Operating Speeds (RPM)** — If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example.)

**3. Operating Radius**—in making the selection from the table below, the radius of the smallest bend in the flexible shaft should be used.

**Ratings** — The ratings for flexible shafts shown in the table below apply under the following conditions:

1. When the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below.)
2. When the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque.)
3. When the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow engineers for specific recommendations.**

| RATED SPEED R.P.M. | MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.) STRAIGHT AND CURVED SHAFTS RADIUS OF CURVATURE IN INCHES | | | | | | | | | Wgt./ C. Ft. | Core Dia. | Core No. and Type | Shaft Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 to Strgt. | 25 | 20 | 15 | 12 | 10 | 8 | 6 | 5 | | | | |
| 4,500 | 2.4 | 2.2 | 2.0 | 2.0 | 1.92 | 1.9 | 1.7 | 1.5 | 1.25 | 3.0 | .124/ 128 | 2049 MH | 13 |
| 3,800 | 7 0 | 6.4 | 6.0 | 5.8 | 5.4 | 5.0 | 4.6 | 3.6 | 2.0 | 4.5 | .148/.152 | 2081 MH | 15 |
| 2,900 | 9.4 | 8.6 | 8.0 | 7.6 | 7.0 | 6.6 | 6.0 | 4.8 | 3.4 | 7.0 | 185/.189 | 5108 MH | 19 |
| 2,500 | 22.0 | 20.0 | 18.8 | 17.6 | 16.0 | 15.0 | 12.6 | 10.8 | 9.0 | 12.5 | .247/.252 | 8924 MH | 25 |
| 1,800 | 30.0 | 28.0 | 26.4 | 25.0 | 23.0 | 21.0 | 18.0 | 14.0 | | 20.0 | .308/.313 | 8925 MH | 31 |
| 1,800 | 33.8 | 31.5 | 29.7 | 28.1 | 25.9 | 23.6 | 20.2 | 15.8 | | 20.0 | .308/.313 | 8969 T | 31 |
| 1,800 | 36.0 | 33.0 | 31.6 | 30.0 | 28.0 | 26.0 | 22.0 | 18.0 | 11.0 | 21.0 | .324/ 329 | 2034 A | 31 |
| 1,500 | 80.0 | 66.0 | 63.0 | 58.0 | 51.0 | 46.0 | 37.0 | 22.0 | | 28.5 | .368/.374 | 2035 A | 38 |
| 1,500 | 60.0 | 54.0 | 50.0 | 46.0 | 42.0 | 38.0 | 30.0 | 24.0 | | 29.0 | .387/.393 | 8970 MH | 40 |
| 1,500 | 90.0 | 81.0 | 75.0 | 69.0 | 63.0 | 57.0 | 45.0 | 36.0 | | 29.0 | .387/.393 | 8971 T | 40 |
| 1,150 | 136.0 | 110.0 | 104.0 | 94.0 | 80.0 | 72.0 | 56.0 | | | 50.5 | .497/.503 | 8999 A | 50 |
| 1,150 | 148 | 124 | 110 | 92 | 72 | 56 | | | | 53.5 | .505/.511 | 6940 T | 50 |
| 900 | 248 | 200 | 176 | 124 | 84 | | | | | 78.5 | .610/.618 | 6997 T | 63 |
| 900 | 220 | 204 | 192 | 180 | 152 | 130 | | | | 80.5 | .630/.638 | 7731 A | 63 |
| 750 | 340 | 224 | 156 | 76 | | | | | | 117 | .747/.753 | 2056 T | 75 |
| 600 | 760 | 520 | 420 | | | | | | | 205 | .998/1.004 | 2057 T | 100 |
| 440 | 1,500 | 720 | | | | | | | | 343 | 1.298/1.304 | 2058 T | 125 |

**EXAMPLE—How to use the table:**

The problem is to transmit ½ HP at 1700 RPM through an unsupported flexible shaft in a 25" radius, estimated starting torque 150% of normal operating torque.

1. Calc. Torque (lb. in.)—
$$\frac{HP \times 63000}{RPM} = \frac{.5 \times 63000}{1700} = 18.5$$
2. Correction factor for starting torque $1.5 \times 18.5 = 27.75$.
3. Correction factor for unsupported shaft $27.75 \times 1.6 = 44.4$ lb. in.
4. Refer to Table above. Read downward in column under 25" radius until you find a core having a rating of at least 44.4 lb. in. In this case we find that Core No. 8970 is rated 54 lb. in. at 1500 RPM. Since the given speed is 1700 RPM, multiply 54 by 1500 and divide by 1700. $54 \times 1500 \div 1700 = 47.6$ lb. in. (rated torque at 1700 RPM). Therefore, Core No. 8970 is correct.

STOW

For Engineering Bulletin No. 570 and a free torque calculator, write
**STOW MANUFACTURING COMPANY**

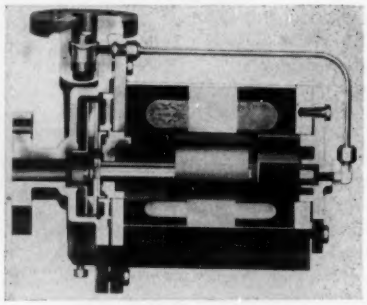
11 Shear Street • Binghamton, New York

has greater resistance to wear and decomposition than many felts produced by other methods. Fiberloc can be produced with any man-made fiber. It is available in Dacron, Orlon, nylon, Viscose, acetate, Arnel, polypropylene, or in various combinations in widths to 108 in. and with thicknesses to 1 in. Permeability is controlled in manufacturing, making material suitable for filtration applications. It has a supporting center with which tensile strengths to 1500 psi are obtained. Fiberloc can be die cut to precision shapes without fraying or raveling. Material resists acids and alkalis, and withstands temperatures to 350 F. Applications include padding, seals, wicks, insulations, reinforcement, filtering, laminates, and gaskets. **Felters Co.**, 1803 Empire State Bldg., New York, N. Y.

*Circle 751 on Page 19*

## *Leakproof Canned Pumps*

**have long bearing life**



Series G leakproof canned pumps incorporate automatic thrust balance design. Combined with larger bearings and radial bearing surfaces, design gives long bearing life. Oil-filled stator cavity effectively dissipates heat from motor windings. **Chempump Div., Fostoria Corp.**, Huntingdon Valley, Pa.

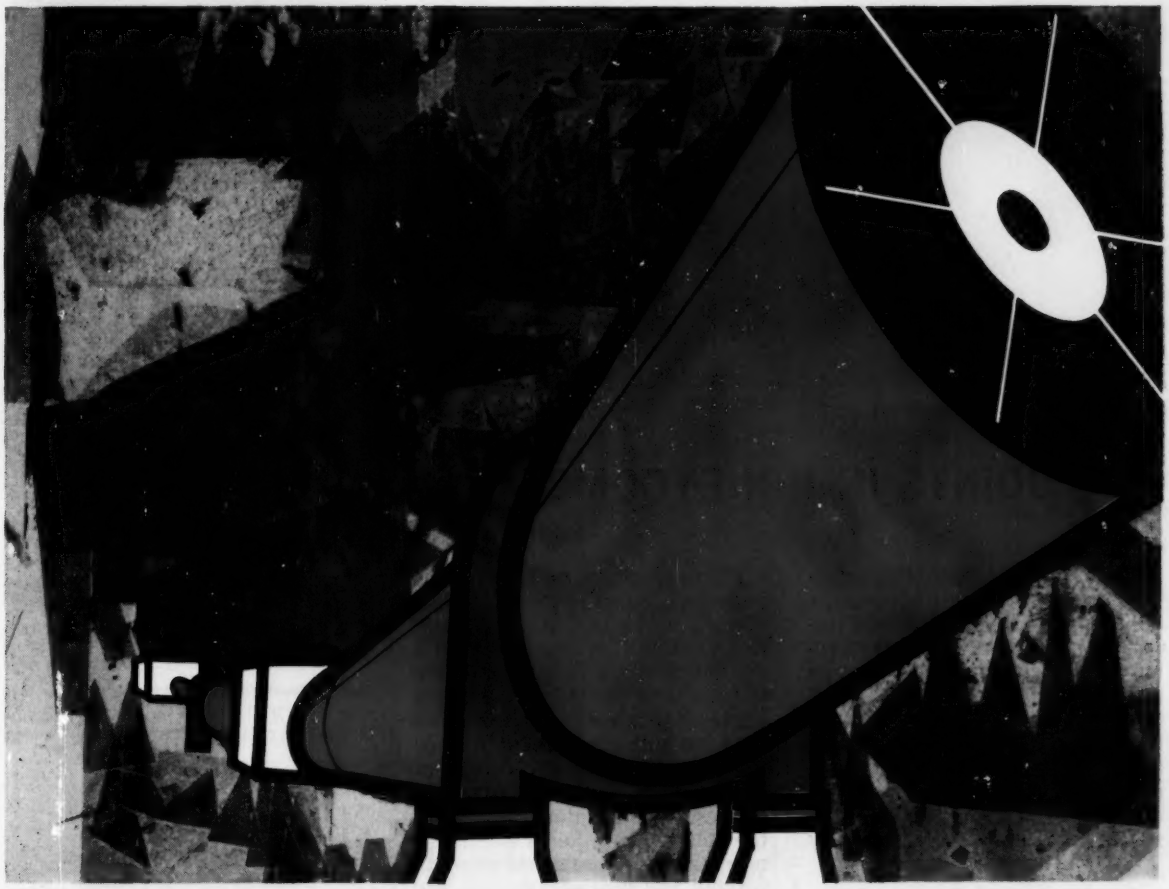
*Circle 752 on Page 19*

## *Snap-Action Thermostat*

**has enclosed contacts and contact members**

Designed for control of temperature in air streams, Norstat Series D snap-action thermostat features exposed bimetal for quick response, and operates on differentials as narrow as 5 F. Contacts and contact members are enclosed for protec-

This mark tells you a product is made of modern, dependable Steel.



# How they built a better penstock with half the steel

Near Chinaman's Peak in the Canadian Rockies, Calgary Power, Ltd., has completed the first penstock in this hemisphere built with USS "T-1" Steel. The 1,601-foot-long, 8' diameter penstock is part of their "Spray No. 2 Project" to produce 50,000 more KW of hydroelectric power for Calgary Power in Alberta, Canada.

Montreal Engineering Co., Ltd., designers of the project, recognized the value of USS "T-1" Steel as an excellent constructional alloy steel for high head penstocks several years ago. After careful study, their engineers specified USS "T-1" Steel for the job because its minimum yield strength of 100,000 psi made possible nearly a 50% savings in the amount of steel required. This saving helped to reduce substantially the transportation and erection costs that would have been required had structural carbon steel been used in this location.

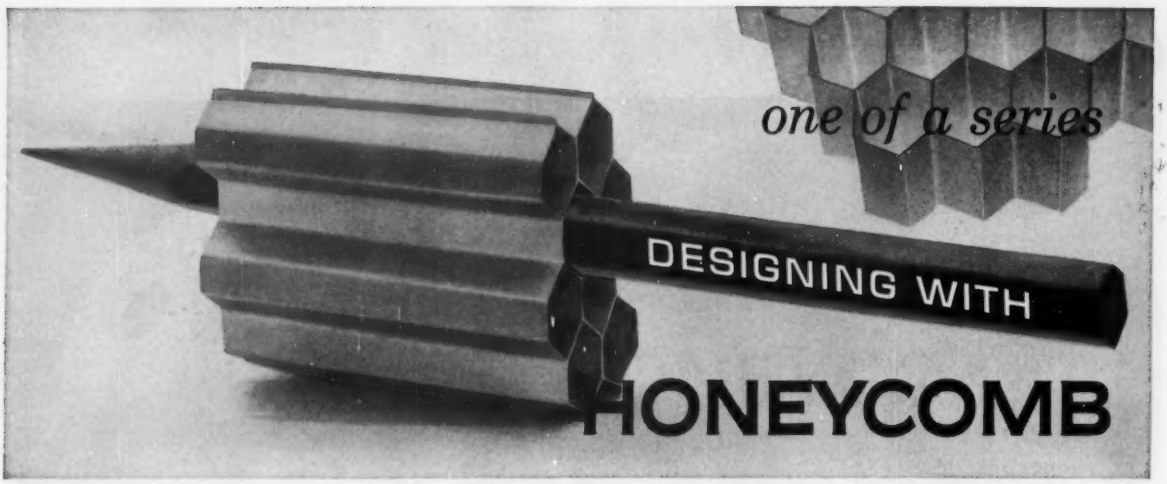
It was significant that the penstock was designed to a 37,000 psi unit working stress (or approximately 41,000 psi unit stress at 90% joint efficiency). This is more than 28% greater than the ASME code case 1204-4 allows for pressure vessels built of "T-1" Steel in United States.

In the new Calgary penstock, 500 tons of USS "T-1" Steel plate 5/16" to 3/4" thick were used by Dominion Bridge to fabricate the segments, or "cans," in its Calgary plant. These segments are 8' to 7' in diameter. Field welding was reduced and lighter fourdations were possible.

**Other applications.** Because of USS "T-1" Steel's exceptional strength, toughness, and high resistance to impact abrasion, it is widely used to build equipment stronger and brawnier but lighter in weight. USS "T-1" Steel is readily weldable, does not require stress relieving and retains its strength even at very low temperatures. Write for a free copy of our book, "The Fabrication and Design of Structures of 'T-1' Steel." United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania. *USS and "T-1" are registered trademarks*

United States Steel Corporation, Pittsburgh • Columbia-Geneva Steel, San Francisco • National Tube, Pittsburgh • Tennessee Coal & Iron, Fairfield, Alabama • United States Steel Supply, Steel Service Centers • United States Steel Export Company

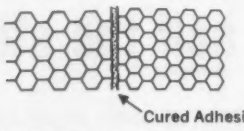
USS United States Steel




# #9 JOINTS IN HONEYCOMB CORE

In the design of sandwich structures, the problem of joints in honeycomb core materials is frequently misunderstood or overlooked. Effective joints are easy to make. They are extremely useful in assembling panels using more than one type or density of core material and in the manufacture of parts larger than those possible with conveniently available core sizes. Most important of all, many common types of joints in honeycomb core are both inexpensive and efficient.

Fig. 1—Adhesive Splice




The most frequently used joint is the butt adhesive joint (Fig. 1). The shear load in the honeycomb core of this joint is transmitted from the cells on one side of the joint through the adhesive material into the nearest cells on the opposite side of the joint. Sprayed adhesives, roller-coated adhesives, or a foaming tape make these joints extremely reliable.

Fig. 2—Y-Butt Splice

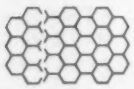
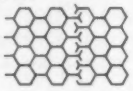


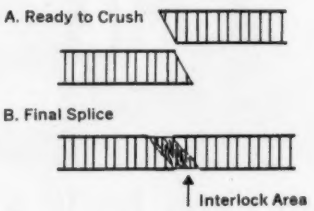

Fig. 3—Y-Interlock Splice




Where electrical performance is important, as in radome applications, a high-strength, nearly perfect joint can be obtained with a Y-butt splice or a Y-interlock splice (Figs. 2 and 3). These joints are somewhat more costly to make than the butt adhesive joint, since they call for careful matching of the cell configuration to maintain the honeycomb pattern throughout the splice. These joints will develop nearly full core shear strength without any applied adhesive and more than full shear strength with only a slight amount of liquid resin adhesive applied to the joint.

The most economical of the commonly used structural joints in honeycomb core material is the crush-splice. To manufacture this joint, one piece of honeycomb is overlapped approximately two cells over a second piece of honeycomb, and the two pieces are crushed together. In some types of fiberglass honeycomb, this joint will develop full core shear strength. In aluminum honeycomb, a small amount of adhesive must be placed in the crushed area in order to develop full shear strength of the core. For thick slices of honeycomb, it is advisable to bevel the edges of the honeycomb in order to achieve a satisfactory interlock without destroying the core to the extent that good shear performance is lost. 30°, 45° or 60° bevels are all effective, but the greater angles are recommended for thicker core slices (Fig. 4).

Fig. 4—Beveled Crush Splice




All of the joints described may be used to join different densities of core together or may be used to join totally different core materials together. The plan layout of the joint can also be widely varied. Many honeycomb fabricators now readily perform once-difficult joining operations such as a butt joint with foam tape, in which three different ribbon orientations and two core densities are joined to make a single part.

See the Hexcel Brochure, **This Is Hexcel Honeycomb,** in Sweet's Product Design Catalog file.

Further information on honeycomb core is available from Hexcel Products Inc. Write Dept. 3-C.

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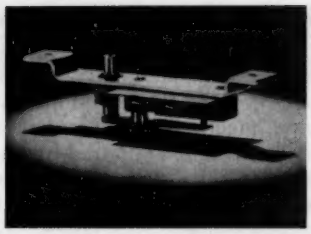


tion against dust and corrosion. Nonadjustable, adjustable, and manual-reset type are available. Applications include air conditioners, refrigerators, furnace fans, fans on rectifiers, electronic and avionic equipment, and industrial apparatus. **Norwalk Thermostat Co.**, 72 Woodlawn Ave., Norwalk, Ohio.

*Circle 753 on Page 19*

### *Mylar Tubing*

**has dielectric strength of 2500 v per mil minimum**

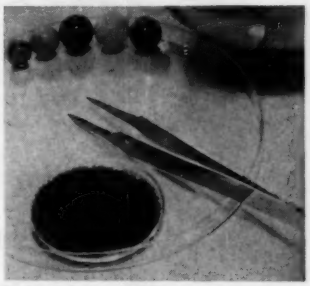
Mylar tubes are now available in IDs from 0.040 to 8 in. Wall thicknesses range from 0.001 to 0.050 in. Tubes have dielectric strength of 2500 v per mil minimum, continuous heat resistance of 300 F, and are rated Class B. They are impervious to common solvents, alcohol, naphtha, toluol, and similar chemicals, as well as to corrosion and fungus. Tubes are available in threaded forms which can be supplied with a polyester coating to protect against possible breakthrough caused by the threading. **Dept. MD-1, Resinite Corp.**, 6984 N. Central Park Ave., Chicago 45 (Lincolnwood), Ill.

*Circle 754 on Page 19*

### *Precision Balls*

**are furnished in special materials**

Precision balls in both prototype and production quantities are furnished in boron carbide, titanium diboride, glass-filled Teflon, Index I, irradiated polyethylene, ferrites, synthetic rubies and sapphires, tantalum, titanium carbide, and high-density aluminum oxides. Balls of these materials extend the range of possible applications in cases where temperature and load extremes, corrosion resistance, magnetic or nonmagnetic qualities, dielectric properties, or controlled density are of major importance. Balls can be furnished in a wide range of sizes, tolerances, and surface finishes. **Technical Services Dept., Industrial Tectonics Inc.**, 3686 Jackson Rd., Ann Arbor, Mich.



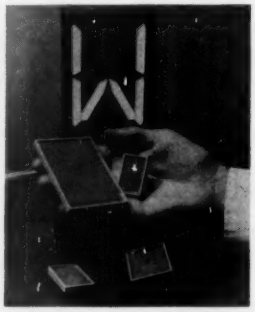
*Circle 755 on Page 19*

### *Readout Lamps*

**produce light by electroluminescence**

Five Rayescent readout lamps display letters and numbers for a wide

variety of applications. Devices produce light by electroluminescence; practically no heat is produced. Letters are formed by energizing specific segments of 14-segment alphabet-type lamps or 10-segment numeric-type lamps. Numerals and letters can be read at distances from 25 to more than 100 ft, depending upon the size of the lamp and ambient lighting condi-



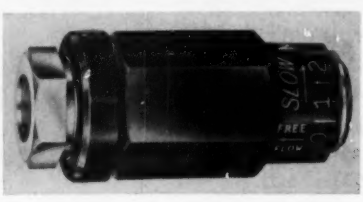
tions. Heights range from ½ to 4 3/16 in. Electrical contact is made through pins molded into the lamps. Lamps operate at either 240 or 460 v and 60 or 600 cps. Useful life is about 5000 hr. Switching and forming of letters and numerals can be accomplished by use of step relays, rotary, solid-state, logic switching, or electromechanical devices. **Westinghouse Lamp Div., Westinghouse Electric Corp.,** MacArthur Avenue, Bloomfield, N. J.

*Circle 756 on Page 19*

## *Flow-Regulating Valve*

**offers high precision in low-flow ranges**

Dyna-Trol pneumatic and hydraulic flow-regulating valve provides fine adjustment in the low-flow range. Flow increases from zero to about 10 per cent of potential during the first 360-deg rotation of the valve adjusting sleeve. Successive rotations of the sleeve produce flow volumes of approximately 30, 65, and 100 per cent. Valve is avail-



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**AUTOMATION** Penton Building/Cleveland 13, Ohio

**The Magazine of Automatic Manufacturing Operations**

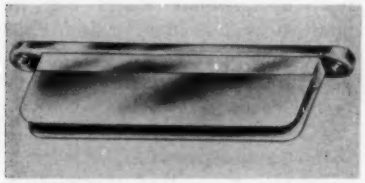
able in 1/8, 1/4, 3/8, and 1/2-in. pipe sizes. Record of established settings is provided by calibrations on the valve-adjusting sleeve, which is easily rotated by hand and held at any point by a locking ring. Valve operates effectively from −40 to +250 F. It accommodates working air pressure to 250 psi and oil pressure to 1000 psi. **Mead Specialties Co.**, 4114 N. Knox Ave., Chicago 41, Ill.

*Circle 757 on Page 19*

## Power Package

**produces electricity directly from heat**

New power package, designated Seejenator, produces usable thermoelectricity. Seejen (shown) is the basic element that produces electricity directly from heat. Any number of Seejens can be connected in series-parallel or any combination into any configuration to create compact power units. Seejenators developed are useful in many applications using low power output. Seejens are available from stock. Seejenators can be designed with simple building-block construction of Seejens into configurations to fit prototypes. Size of a Seejen is 6 x 1½ x 3/8 in., and weight is 1½ oz. Resistance is 100 ohms and voltage at 200 F differential is 1 v. Power output is 2.5 mw, and current into 100 ohms is 5 ma. **Harco Laboratories Inc.**, New Haven, Conn.

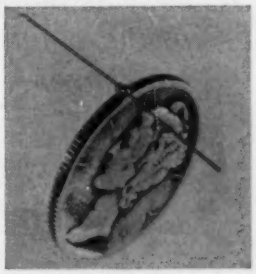


*Circle 758 on Page 19*

## Miniature Hermetic Diodes

**two units have 0.040-in. diam**

Two microminiature glass diodes, designated Micro/G TI-2 and TI-6, are computer diodes with applications in diode gates, transistor-diode logic circuits, diode logic circuits, and high-speed switching. Package diameter of 0.040 in., length of 0.060 in., and incorporation of round leads provide a reduction in



volume of 50:1 over conventional diodes with similar characteristics. Reverse recovery times of the TI-2 and TI-6 are 10 and 100 nanoseconds respectively. **Semiconductor-Components Div., Texas Instruments Inc.**, P. O. Box 5012, Dallas 22, Tex.

*Circle 759 on Page 19*

## Miniature Blower

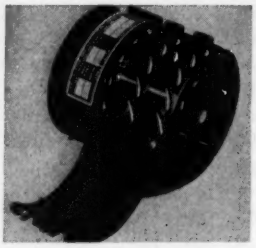
**has 3 in. diam and weighs 29 oz**

Stax-3-FC 3-in. diam blower uses compressor staging principles to deliver 39 cfm of air against system





*Circle 493 on Page 19*



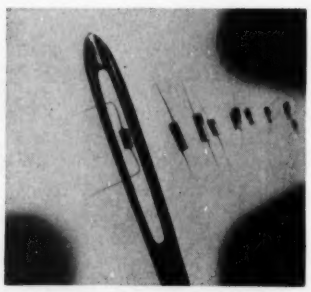
resistance of 14 in. water. Unit is designed for use with heat exchangers, transistor cold plates, and crowded electronics enclosures. Low specific speed indicates use in place of large radial-wheel centrifugal blowers rated to 1/4 hp. Blower operates on 200 v ac, 400 cps, but other power variations can be supplied. Units are designed to meet MIL specs, and mount by clamping to servo ring. One, two, or three compression stages can be mounted in the same housing. Unit is 3 in. long and weighs 29 oz. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio.

*Circle 760 on Page 19*

## *Tantalum Capacitors*

**for microminiaturized uses**

New solid-slug tantalum capacitors with length over insulation ranging from 0.150 to 0.240 in. and diameter from 0.065 to 0.070 in., are suited for microminiaturized applications. TS types display a long service life through a temperature range of −55 to +85C and long shelf life at temperatures from −80 to +125 C. Temperature tolerance allows the capacitors to withstand assembly temperatures to 125 C. Body is made of an epoxy compound, to which color has been added to identify polarity. Epoxy encapsulation also protects welded leads during assembly operations. Capacitances and working voltages of the capacitors range





*Circle 494 on Page 19*

# Are your bookkeepers better equipped than your engineers or draftsmen?

You certainly want your bookkeeping department to have the latest equipment to maintain accuracy and output—but your highly trained professional engineers or draftsmen need today's tools, too—for the high production efficiency you've a right to expect.

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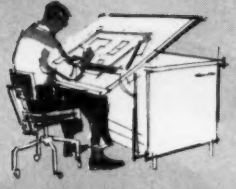
**Hamilton Unit System Files**
Provide full protection, accessibility, and classification for all materials to be filed. Occupy minimum floor space.



**Hamilton Auto-Shift Table**
Built-in mechanism adjusts board to individual height and slope requirements, provides full accessibility, reduces errors.

**Hamilton CL 100 Drafting Table**
Conserves dollars, yet rugged canted-leg design provides modern styling and convenience with long-term durability.

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from 0.01 mfd and 15 v to 20 mfd and 4 v, respectively. **Tansitor Electronics Inc.**, West Road, Bennington, Vt.

Circle 761 on Page 19

### Relief Valve

**operates at pressures from 850 to 7200 psi**

Series 5300 relief valve provides high flow characteristics, cracking-pressure accuracy, and tight sealing. Valve operates at pressures from 850 to 7200 psi and temperatures from −40 to +200 F. It provides tight sealing to well above 95 per cent

of the preset cracking pressure. External adjustment permits varying the cracking pressure to meet circuit requirements, and interchangeable springs permit change of entire cracking pressure range. **Circle Seal Products Co. Inc.**, 2181 E. Foothill Blvd., Pasadena, Calif.

Circle 762 on Page 19

---

The following item, originally run in our Feb. 16 issue, contained an inaccuracy. It is being rerun with corrected text.

### Instrument Coupling

**is all-speed, flexible unit**

Superprecision instrument coupling has a high degree of accuracy and efficiency. It answers the need for an efficient, precise, all-speed, flexible coupling. Absence of moving and wearing parts assures its unusual speed and life expectancy. While permitting linear and angular misalignments, without angular backlash, coupling allows parallel hub displacement. It also provides extremely close concentricity between both hub bores. **Santa Fe Instruments Inc.**, 2343 Jerome Ave., New York 68, N. Y.

Circle 763 on Page 19

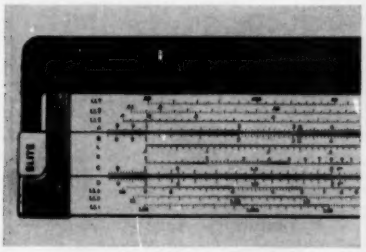
ENGINEERING DEPARTMENT

# EQUIPMENT

## *Slide Rule*

**of laminated bamboo has extended log-log scales**

Elite slide rule is treated laminated bomboo, with ivory white plastic facing. Bomboo neither contracts nor expands with changes in temperature or climatic conditions, and is self-lubricating. Problems involving fractional or nonintegral powers, and roots of integral or nonintegral quantities are easily solved with extended range of log-



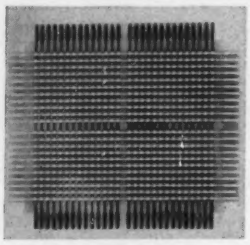
log scales. Color-coded scales and reference symbols simplify and speed the co-ordination scale readings. Rule is available in three 10-in. models for mechanical engineer, advanced electronics engineer, and scientist. New 5-in. log-log deci-trig pocket model is also available for advanced electronics use. **Alvin & Co. Inc.**, 611 Palisado Ave., Windsor, Conn.

*Circle 764 on Page 19*

## *Printed-Circuit Board*

**permits a large variety of circuit arrangements**

All-purpose matrix printed-circuit board lends itself to experimental and prototype work. Pattern provides a complete set of physically perpendicular circuit connections on both sides of the board. Corresponding holes are provided at each intersection for wiring. In conjunction with the standardized insertion strips, board permits preparation of customary, cross-over, bus bar, and



transposition configurations. Variety of circuit arrangements can be made through the use of the board as it is. Boards can be keyed to insure correct insertion into printed circuit connectors and are available to fit 22 or 28-contact receptacles on 0.156 centers. **Spec-Tronics Inc.**, 13901 Saticoy St., Van Nuys, Calif.

*Circle 765 on Page 19*

### *Meter-Indicator*

**for use with strain-gage transducers**

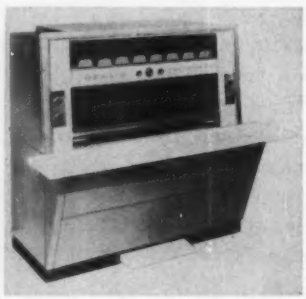
Model 470 meter-indicator provides continuous indication of pressure, torque, force, weight, or flow when used in conjunction with strain-gage transducers of bonded or unbonded type. Unit includes transistor amplifier, power supply, and wide-scale meter, eliminating the necessity for additional instrumentation. Variety of features can be adapted to any special purpose requirement. Accuracy is ±1 per cent. **Bytrex Corp.**, 50 Hunt St., Newton 58, Mass.

*Circle 766 on Page 19*

### *Whiteprint Machine*

**has sleeveless developing system**

Printmaster 900 reproduces engineering and architectural drawings, visual-aid materials, and a wide variety of business forms. It accommodates materials of any length

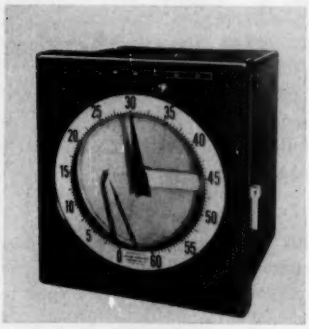


up to 42 in. wide. Printing and developing speeds are synchronized to 75 fpm. Sleeveless dry-diazo developing system assures scratch-proof protection of sensitized films and eliminates the need for slip sheets. Variable-speed control, lamp-intensity switch varies light output from 4500 to 7500 w. Cooling system permits processing plastic-coated materials and foil without their sticking in the printing sections of the machine. Unit is wired for 220 v ac, 60 cycles, single phase. **Ozalid Div., General Aniline & Film Corp.**, 69 Corliss Lane, Johnson City, N. Y.

*Circle 767 on Page 19*

### *Recorder-Controllers*

**require only an external sensing device**



Double-O round-chart recording and indicating controllers are completely self-contained, null-balancing instruments requiring only an external sensing device. Wide range of models is available for the measurement, indication, control, and permanent recording of temperatures. With proper circuitry and the use of transducers, such variables as speed, strain, hydrogen ion, and other quantities which can be resolved into electrical signals can be recorded and controlled. Swing-away design allows easy access for quick change of range, control form, cross-chart speed, charts and all major or adjustable components. Line gives 0.50 per cent accuracy for all scale spans in pyrometric range. All thermocouple and radiation pyrometer ranges down to 5 mv full scale are available. **Wheelco Industrial Instruments Div., Barber-Colman Co.**, Rockford, Ill.

*Circle 768 on Page 19*

THE ENGINEER'S

# Library

## Recent Books

**Transistors: Principles, Design, and Applications.** *By Wolfgang W. Gartner; 675 pages, 6¼ by 9¼ in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, *$12.50 per copy postpaid.*

Transistor circuit-design theory and applications are described. More than 300 circuit diagrams illustrate typical circuits and the principles underlying transistor design.

An introduction to solid-state physics and semiconductor properties is presented first. Then, transistor design theory is developed—physical properties and geometry of transistors are related to electrical characteristics. Finally, transistor applications are thoroughly discussed.

**An Engineering Approach to Gyroscopic Instruments.** *By Elliott J. Siff and Claude L. Emmerich; 120 pages, 6¼ by 9¼ in., clothbound; published by Robert Speller & Sons Publishers Inc., 33 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 per copy postpaid.*

Fundamental principles of gyroscopic instruments are discussed first. Then, these principles are applied to basic gyro configurations that form the foundation of most present-day gyroscopes. A few special designs are presented: Electrostatic and electromagnetically supported gyros, air bearings, vibrating gyros, and particle gyros.

**Reflections on the Motive Power of Fire.** *By Sadi Carnot; 152 pages, 5½ by 8 in., paperbound; published by Dover Publications Inc., 180 Varick St., New York 14, N. Y.; $1.50 per copy.*

Foundations for modern thermodynamics were provided by Carnot in 1824 when this book was first published in French. Carnot's theories and experiments with heat and its applications are covered.

This latest English edition was edited by E. Mendoza and is an un-

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Circle 501 on Page 19

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abridged but corrected republication of the book translated and edited by R. H. Thurston in 1890. Selections from Carnot's posthumous manuscripts and two papers on the second law of thermodynamics by E. Clapeyron and R. Clausius are included.

**A Dictionary of Named Effects and Laws in Chemistry, Physics & Mathematics.** *By D. W. Ballentyne and L. E. Q. Walker; 234 pages, 5¾ by 8¼ in., cloth-bound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$6.00 per copy postpaid.*

A glossary of terms having specific and unique meanings to a particular scientific subject is presented. Typical definitions include Bernoulli's equations, Euler's numbers, Joule's law, Lagrange's equations of motion, Newton's laws of motion, and Young's modulus.

This second edition is a revised and expanded version of the original 1958 edition. About 150 new definitions have been added.

## *Government Publications*

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

**PB 151898. Notch Sensitivity and Laminated Charpy Impact Strength of 1100-F and 2024-T4 Aluminum Alloy Simulated Sheet.** By S. V. Arnold; 24 pages, 8¼ by 10¾ in., paperbound, side-stapled; $0.75 per copy.

Simulated sheet of 1100-F and 2024-T4 aluminum alloys was fashioned in 0.05 to 0.2-in. gages. Laminted Charpy specimens 0.4-in. thick were assembled from this simulated sheet and tested over the range −196 C to +400 C. Notched and unnotched specimens were tested at room temperature.

**PB 161788. High-Temperature Insulation for Wire.** By J. N. Harris and J. D. Walton Jr., Engineering Experiment Station of the Georgia Institute of Technology; 40 pages, 8¼ by 10¾ in., paperbound, stapled; $1.00 per copy.

A high-temperature frit-resin insulation coating for electric wire was developed. Coating has low dielectric constant, low dissipation factor, and good continuity. Wire properly treated with the coating was still capable of operating after 750 hr at 800 F.

**SB 409. Metal Coatings (1950-1960).** 20 pages, 8 by 10¼ in., paperbound, stapled; $0.10 per copy.

This selective bibliography lists research reports and translations on development, preparation, and application of protective and insulating coatings for steel, iron, tin, molybdenum, aluminum, magnesium, and other metals and alloys. Electroplating, electrodeposition, electropolishing, vapor and vacuum deposition, plating and phosphate coatings, and government-owned patents available for license are covered.

**SB 415. Molybdenum and Tungsten.** 18 pages, 8 by 10¼ in., paperbound, stapled; $0.10 per copy.

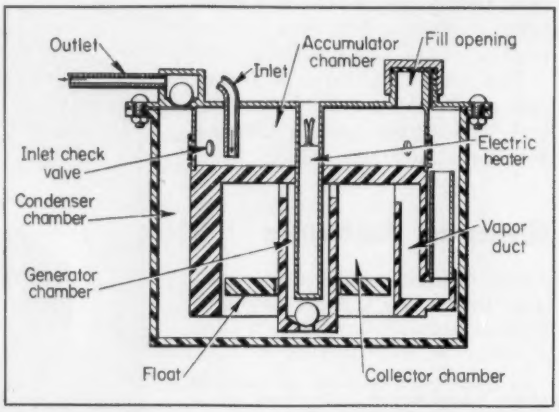
Alloy formation, powder-metallurgy techniques, tensile properties, creep-rupture effect of heat, and other reports on molybdenum and tungsten metals and alloys are covered in this selective bibliography. A list of government-owned patents available for license is also included.

NOTEWORTHY

# Patents

### *Heat-Actuated Pump*

In a liquid pump, the working fluid is alternately vaporized and condensed to produce volumetric changes which induce flow through a number of check valves. The space inside the pump shell is divided into several chambers. A heating element is centrally located in a liquid-tight housing. When the pump is filled, liquid flows from the accumulator chamber into the condenser and generator chambers. When heated, the fluid in the generator chamber vaporizes and fills the collecting chamber, causing the float to move downward. The liquid below the float is forced downward initially and then upward through the condenser chamber and the discharge valve. The liquid levels in the collector

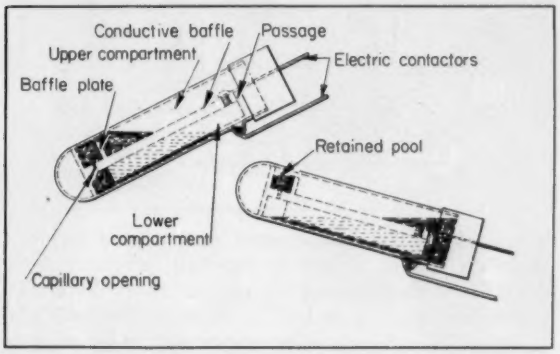



chamber and vapor duct continue to fall until the vapor reaches the lower end of the vapor duct. Then, the hydrostatic balance is lost, and liquid rising in the collector chamber forces the vapor in the duct into the condenser chamber. When the vapor is condensed, the inlet valves open under the partial vacuum produced to refill the pump. After the pump refills, the cycle is repeated. *Patent* 2,969, 747 *assigned to Jet-Heet Inc., Englewood, N. J., by Calvin D. MacCracken.*

### *Time-Delay Mercury Switch*

A pool of mercury is metered through a capillary opening to provide a uniform time delay for opening or closing an electric circuit. A horizontal conductive baffle divides the body of the switch into two compartments with an end passage which permits free flow of mercury between the upper and lower compartments. A vertical baffle extending from the horizontal baffle provides a third compartment which contains a capillary opening at its base. No mercury will flow from this compartment until it is united with the mercury in the lower compartment. The switch is instantaneously closed for a small angle of tilt by the flow of

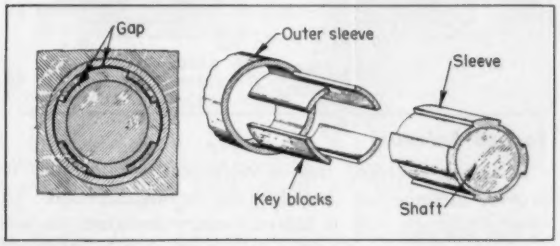
mercury in the lower compartment. When the switch is returned to the nonconducting position mercury will flow by gravity through the capillary opening into the upper compartment until the level in the upper and lower compartments is the same. Rate of flow is controlled by capillary action to produce a time delay.




This time delay may be varied by changing, either singly or in combination, the size of the capillary opening, the amount of mercury in the tube, or the length of the tube. *Patent* 2,972,025 *assigned to Draper Corp., Hopedale, Mass., by Waldo H. Banks.*

### *Temperature-Compensated Journal Bearing*

In a journal construction, a sleeve with one coefficient of expansion is mounted on a press-fit shaft and sleeve assembly with a different coefficient of expansion. The inner pressed sleeve is slotted to receive key blocks of the same material as the outer sleeve. The outer sleeve is shrunk fit to force the blocks firmly against the radial walls of the slots. As the temperature increases,




differential expansion of the parts forces the key blocks to move inward closing the circumferential gaps provided. Although the physical size of these parts changes at different rates, line contact is maintained since all expansion must follow radial lines. *Patent* 2,970,019 *assigned to United Aircraft Corp., East Hartford, Conn., by Robert G. W. Brown, Lee P. Farnsworth, George P. Fulton, Philip L. Gagner, and Jack M. Tarbox.*

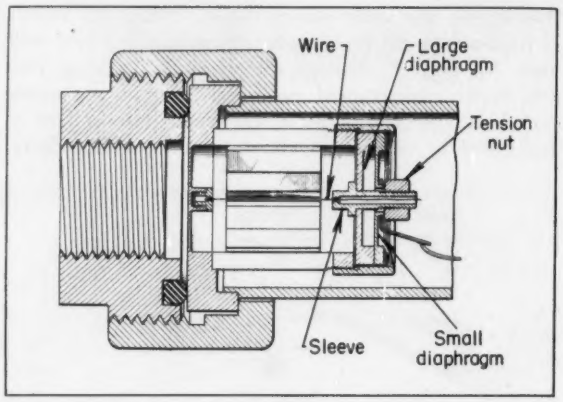
### *Stress Adjusting Mechanism*

Two metal diaphragms of different thickness are tandem mounted to provide a fine adjustment for altering the tensile stress in a wire. The inner diaphragm is approximately three times as thick in cross-section as the outer diaphragm. As an adjusting nut

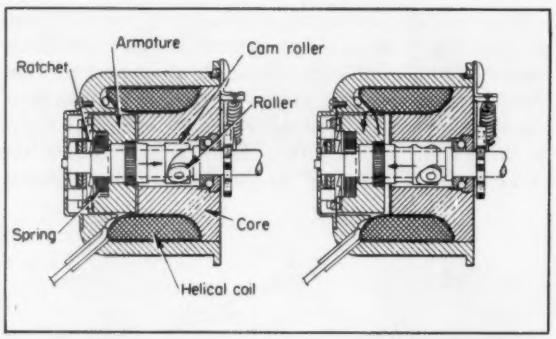




Circle 504 on Page 19




is rotated, the two diaphragms are squeezed together. Since diaphragm flexure is generally proportional to the cube of diaphragm thickness, the inner diaphragm will deflect only about 1/27 as much as the outer diaphragm. Therefore, a relatively large number of turns of the adjusting nut will move the sleeve to which the wire is attached only a short distance. The thickness ratio of the diaphragms can be changed to alter the coarseness or fineness of adjustment. *Patent* 2,969,677 *assigned to Borg-Warner Corp., Chicago, Ill., by Alvin V. Lewis.*




### *Torque Solenoid*

A torque solenoid uses a reciprocating armature to provide incremented shaft rotation in one direction. An electromagnetic coil is intermittently energized to impart axial movement to the armature. A tubular member, integrally mounted to the armature and surrounding the shaft, has a cam surface which engages rollers on the output shaft to produce a rotary motion. When the coil is de-energized, a spring returns the armature to its initial position. As the armature returns, it is rotated by a pawl-and-ratchet mechanism to position the cam surface for the next energization. A change of cam shape to vary the angular increment of rotation produces a corresponding change in the torque delivered to the output shaft. *Patent* 2,963,915 *assigned to Illinois Tool Works, Chicago, Ill., by Joseph E. Straub.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

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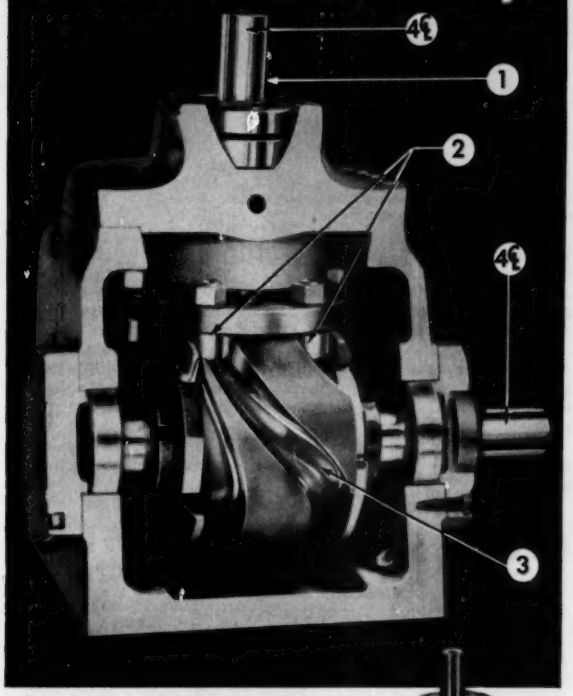


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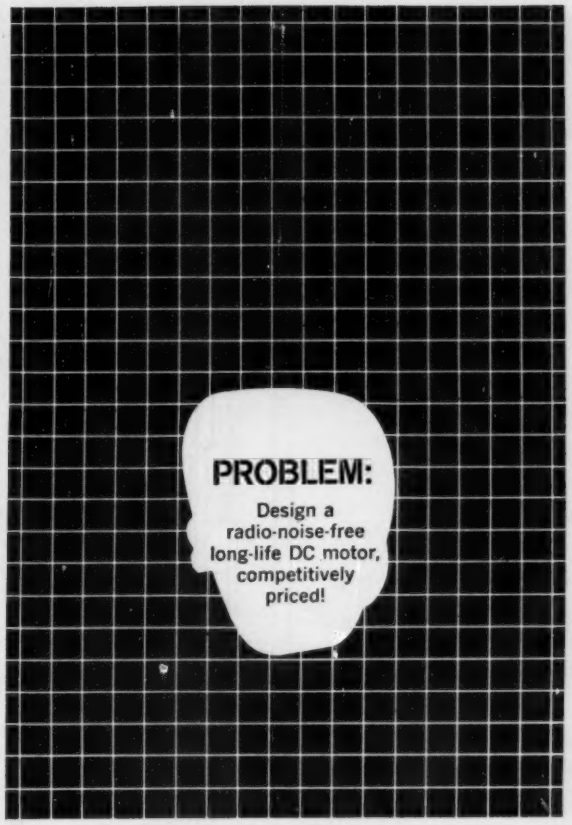


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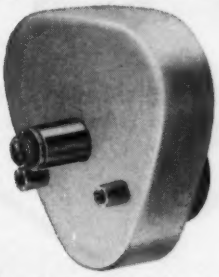

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*Circle 506 on Page 19*

*Circle 507 on Page 19*

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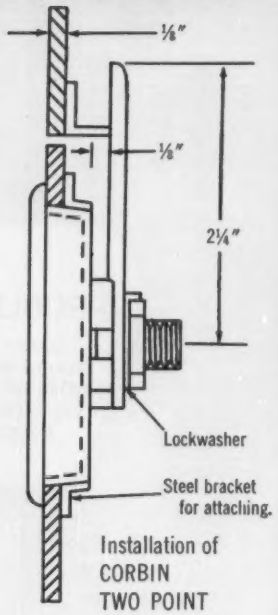


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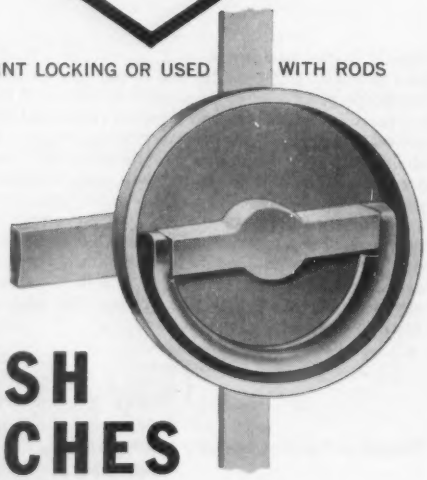


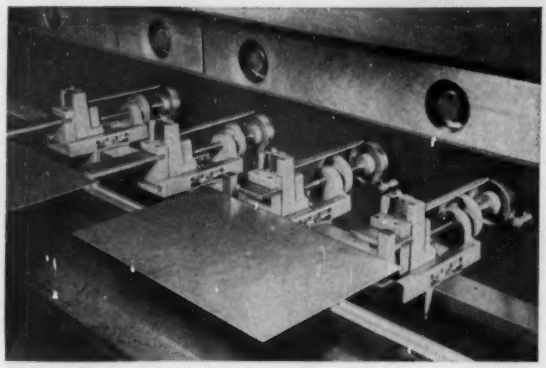
2 POINT
•
3 POINT

# FLUSH CATCHES



Circle 508 on Page 19

# NEW PRESS BRAKE GAUGE



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Circle 509 on Page 19

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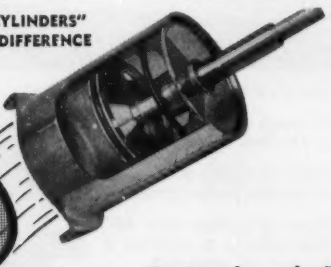

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Circle 510 on Page 19

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*Circle 511 on Page 19*

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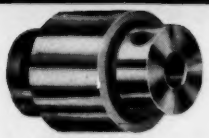

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**Standard Duty Type**

**SERIES FCC**
**Disconnect Type**

Announcing an entirely new way to handle shaft misalignment problems. Fourdee flexible couplings and universal joints combine truly self-aligning ball and socket design principle with high standards of strength and reliability. Available in a wide, variety of models and sizes, units are commonly used where compact size, high torque, tight backlash and unfavorable misalignment conditions are essential considerations.

**MIDGET** — Small, low cost rugged coupling for unlimited use in light duty applications. Unique torsion spring design cushions starting and braking loads. Permits 5° angular offset and 1/32" shaft misalignment. Zero backlash. Lots of 10—$1.90 each.

**4D FOURDEE, INC.**
BOX 6006 ORLANDO, FLA.

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---

AMERICAN AIR CURTAIN CORPORATION

April 14, 1960

# WHY MR. ERNEST GYGAX,

***Chief Engineer for***
***American Air Curtain Corporation***

# SPECIFIES 'BUFFALO' BLOWERS

Buffalo Forge Company
P. O. Box 985
Buffalo 5, New York

Gentlemen:

Buffalo Forge "Blowers" have been used as a result of experience from the standpoint of dependability, service, quality and adaptability to design.

The cooperation given us by Buffalo Forge makes it possible for us to meet the shipping dates specified by our customers, and gives us the feeling of knowing we'll get the job done.

Very truly yours,

AMERICAN AIR CURTAIN CORPORATION

Ernest Gygax

Ernest Gygax
Vice President-Chief Engineer

Egyx

**HOW AMERICAN AIR CURTAIN DOOR WORKS:** Directional nozzles send air downward from ceiling of entrance. Air passes across entrance and is drawn through a floor grill into a pit. From pit, the air passes through filters and a heating element. A blower then directs the air upward to the nozzles to repeat and continue the cycle.



***Like Mr. Gygax,*** you can depend on 'Buffalo' Engineers for complete cooperation and expert advice in your special design problems.

And like Mr. Gygax, you can rely on 'Buffalo's' 83 year reputation for quality — in engineering, construction and service.

Contact your nearby 'Buffalo' Representative. He'll gladly help you solve your air moving problems. Or write us direct.

"Buffalo"

AIR HANDLING DIVISION
**BUFFALO FORGE COMPANY**
Buffalo, New York
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

*'Buffalo' Air Handling equipment to move, heat, cool, dehumidify and clean air and other gases.*

*'Buffalo' Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.*

*'Buffalo' Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.*

*Squier Machinery to process sugar cane, coffee and rice. Special processing machinery for chemicals.*

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*Circle 524 on Page 19*

# ENGINEERS AVAILABLE OR WANTED

**WANTED: SENIOR PROJECT ENGINEER. A leading midwest manufacturer of food packaging has an opportunity for a graduate mechanical engineer with at least ten years experience in the design and development of automatic packaging machinery and allied equipment. This position would require board design, coordination of customer requirements with sales and product development, supervision of draftsmen and engineers, assistance to shop during construction and assembly as well as testing and development work. If you can qualify and are interested in real creative design responsibility in this highly specialized field, you are invited to submit a detailed resume to: MACHINE DESIGN, Box 989, Penton Bldg., Cleveland 13, Ohio.**

# Advertising Index




MACHINE DESIGN

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

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BPA NBP

# backtalk——

## — With Malice Toward Sums

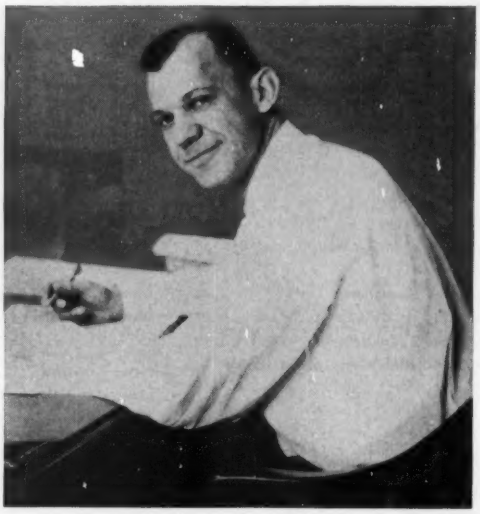
Since it's almost time to start thinking about filling in and returning those forms which the Internal Revenuers sent us earlier in the year, here is some appropriate prose to set the mood:

> Two score and some years ago our fathers brought forth upon this nation a new tax, conceived in desperation and dedicated to the proposition that all men are fair game.
>
> Now we are engaged in a great mass of calculations, testing whether that taxpayer or any taxpayer so confused and so impoverished can long endure.
>
> We are met on Form 1040. We have come to dedicate a large portion of our income to a final resting place with those men who here spend their lives that they may spend our money.
>
> It is altogether anguish and torture that we should do this, but in a legal sense we cannot evade; we cannot cheat; we cannot underestimate this tax. The collectors, clever and sly who compute here, have gone far beyond our power to add or subtract.
>
> Our creditors will little note nor long remember what we paid here, but the Internal Revenue Service can never forget what we report here.
>
> It is for us taxpayers rather to be devoted here to the tax return which the government has thus far so nobly spent. It is from these vanquished dollars that we take increased devotion to the few remaining; that we here highly resolve that next year shall not find us in a higher income bracket; that this taxpayer, underpaid, shall figure out more deductions, and that taxation of the people, by the Congress, and for the government shall not cause our solvency to perish from the earth.

Cleveland Letter Service Inc. furnished the copy; its author is not identified, but his style is familiar.

## — New Face of 1961

We could claim that Leonard B. Stanley, who became an assistant editor of MACHINE DESIGN several weeks ago, was very much at sea before joining our staff. He graduated from high school during World War II and immediately entered the Merchant Marine Academy, where they taught him to be a marine engineer. Serving as a Merchant Marine officer, which he did for two years, automatically made Len a lieutenant in the Naval Reserve; this status, in turn, put him back into uniform shortly after he left the Merchant Marine. He also served in the Navy during the Korean action.



Len finally left military service in 1959 but stayed in Norfolk, Va., where he had been stationed, for about a year, providing engineering services to the various shipyards. During this time he also became interested in Norfolk's newspaper, the *Virginian Pilot,* and did some free-lance cartooning for its editorial pages. Just before joining our staff, he worked for Aeroquip Corp., Jackson, Mich.

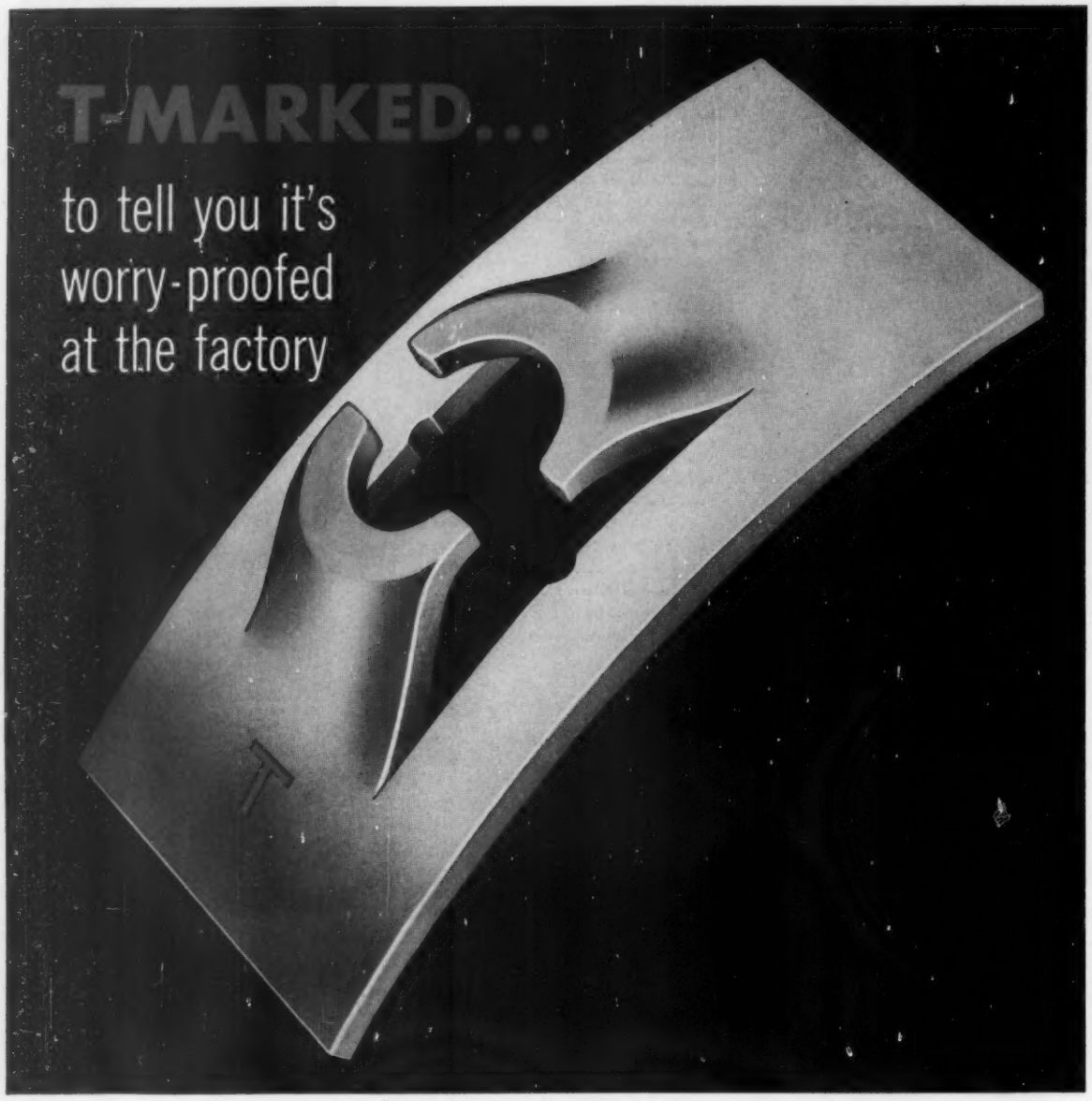
As soon as he is fully settled and has located his drawing paper and pencils, Len plans to put down some cartoon ideas he has in his head. Provided, of course, he doesn't come across his golf clubs or fishing equipment first.

## — Some Good Joints

Next month is National Welded Products Month. Proclamations to this effect by governors and mayors all over the U. S. will "give official recognition to the men, methods, and processes which have contributed so much to the American way of life," says the American Welding Society.

We are celebrating the event by publishing an article on welded joints in the next issue—Part 2 of "Fatigue in Metal Joints," by Ralph G. Crum. If you hurry, you can turn to Page 108 of this issue and read Part 1, on mechanical joints, before NWP month arrives.

# Advertising Index




Other spring fasteners may look like Tinnerman SPEED NUTS. But only the *T-marked* ones really are SPEED NUTS . . . really are "Tinnermans". . . made to highest quality and precision standards to assure worry-proof performance on your assembly.

Here's what the exclusive Tinnerman T-mark means to fastener users:

Over thirty-five years of Tinnerman experience as the originator and largest producer of spring-steel fasteners...the leader in solving your fastening problems,

Outstanding fastener design and production experience that assures you the best possible design of SPEED NUT, whether it is a special SPEED NUT or one of the 10,000 SPEED NUT brand fasteners presently available,

Stringent control of SPEED NUT quality from coil strip to you, including die design, production, heat treatment and finishing.

Be sure you specify "Tinnerman T-marked SPEED NUTS" that give you better fastening, that cut parts and assembly costs, that never let you or your customer down. *Tinnerman Products, Inc., Dept. 12, Box 6688, Cleveland 1, Ohio.*

# strength

# the LION and the MOUSE

A mouse wandered into a lion's cave by mistake. The lion placed his huge paw upon the mouse, and was about to eat him when the victim squealed: // "Forgive me, king of beasts, I did not know where I was! If you let me go just this once, I may be able to do you a good turn some day." The lion, tickled by the idea of a little mouse helping the mighty king of beasts, freed his frightened friend. // Later, the lion was entrapped in a rope net left by hunters. His roars filled the forest. The mouse recognized his voice and ran to help. The mouse set to work gnawing the ropes, and in a short time the lion was free.

## moral: Small size may prove great strength.

Sometimes, small size can be a big advantage. High-speed assembly machines, for example, need small cylinders in order to save space and maintenance costs. That's why we have designed a new line of strong, 1"-bore cylinders for air service to 150 psi.

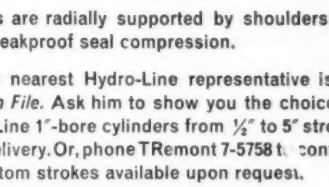
A Teflon rod seal and wiper combination in this cylinder requires no lubrication, resists all corrosives. Low co-efficient of expansion in Teflon piston seals increases cylinder efficiency and reliability. Barrel seals are radially supported by shoulders on barrel ends to insure leakproof seal compression.

The address of your nearest Hydro-Line representative is in *Sweet's Product Design File.* Ask him to show you the choice of mountings for Hydro-Line 1"-bore cylinders from ½" to 5" stroke, ready for immediate delivery. Or, phone TRemont 7-5758 to contact the factory direct. Custom strokes available upon request.

HYDRO-LINE

**HYDRO-LINE CYLINDERS**

5602 PIKE ROAD, ROCKFORD, ILLINOIS, manufacturers of:
high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • boosters • rod end couplers



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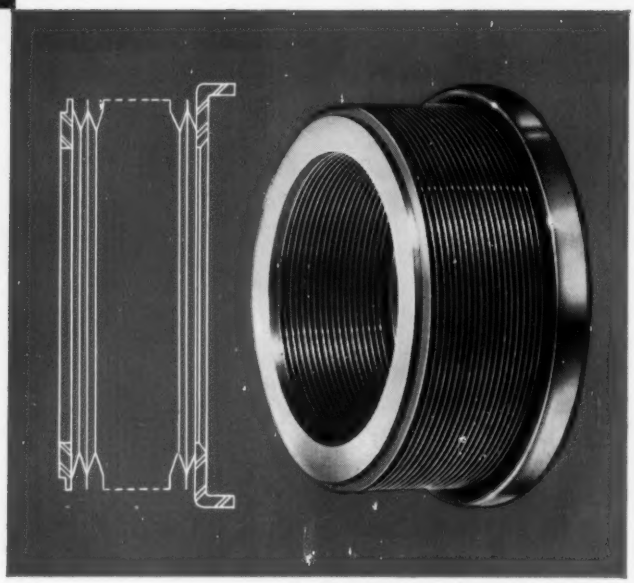
C/R DESIGN NOTES

# How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



## Operating Ranges

| | |
|---|---|
| Temperature | −400° to 1000° F. |
| Pressure | 500 psi |
| R.P.M. | 80,000 plus |

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

## Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

## Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

## Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

## Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

***Helpful Design Data:***

*We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.*

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**CHICAGO RAWHIDE MANUFACTURING COMPANY**

1221 Elston Avenue • Chicago 22, Illinois

*Offices in 55 principal cities*

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